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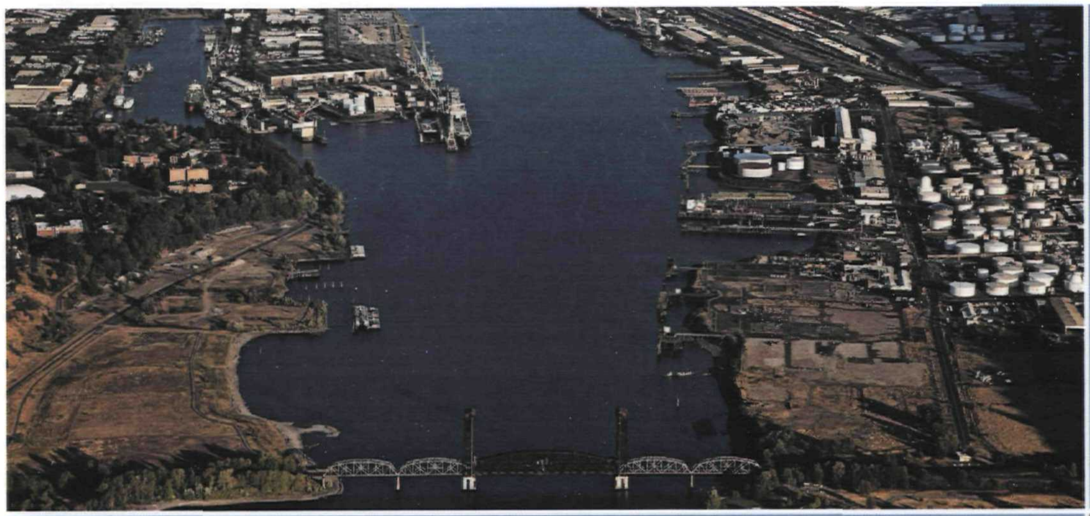
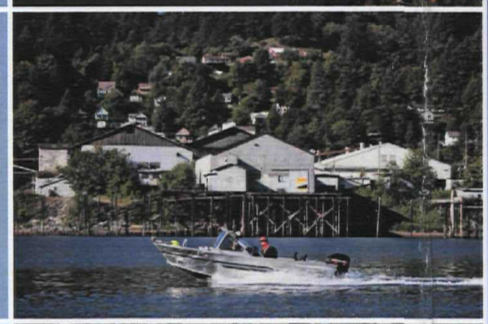


Portland Harbor RI/FS

Draft Remedial Investigation Report

October 27, 2009



VOLUME 11
Appendix D

Prepared for
The Lower Willamette Group

Prepared by
Integral Consulting Inc. • Windward Environmental LLC
Kennedy/Jenks Consultants • Anchor QEA, LLC

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
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PORTLAND HARBOR RI/SF
DRAFT REMEDIAL INVESTIGATION REPORT
APPENDIX D1.2, APPENDIX D1.5, APPENDIX D2.2, APPENDIX D3.2, APPENDIX D4,
APPENDIX D5.1, APPENDIX D6.1
10/27/2009

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PORTLAND HARBOR RI/FS

REMEDIAL INVESTIGATION REPORT

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IC09-0003

RECOMMENDED FOR INCLUSION IN ADMINISTRATIVE RECORD

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PORTLAND HARBOR RI/FS
REMEDIAL INVESTIGATION REPORT

APPENDIX D1
SURFACE AND SUBSURFACE SEDIMENT

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Appendix D1.1

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REMEDIAL INVESTIGATION REPORT

APPENDIX D1.1
SURFACE AND SUBSURFACE CHEMISTRY MAPS (FOR ICs NOT PRESENTED IN MAIN REPORT) (SEE MAP FOLIOS, VOLUMES 13 AND 14)

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Appendix D1.2

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REMEDIAL INVESTIGATION REPORT

APPENDIX D1.2
SEDIMENT SUMMARY STATISTICS FOR ALL ANALYTES (ON CD)

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Appendix D1.3

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REMEDIAL INVESTIGATION REPORT

APPENDIX D1.3
SURFACE AND SUBSURFACE SEDIMENT SCATTER PLOTS (FOR ICs NOT PRESENTED IN MAIN REPORT)

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LIST OF FIGURES

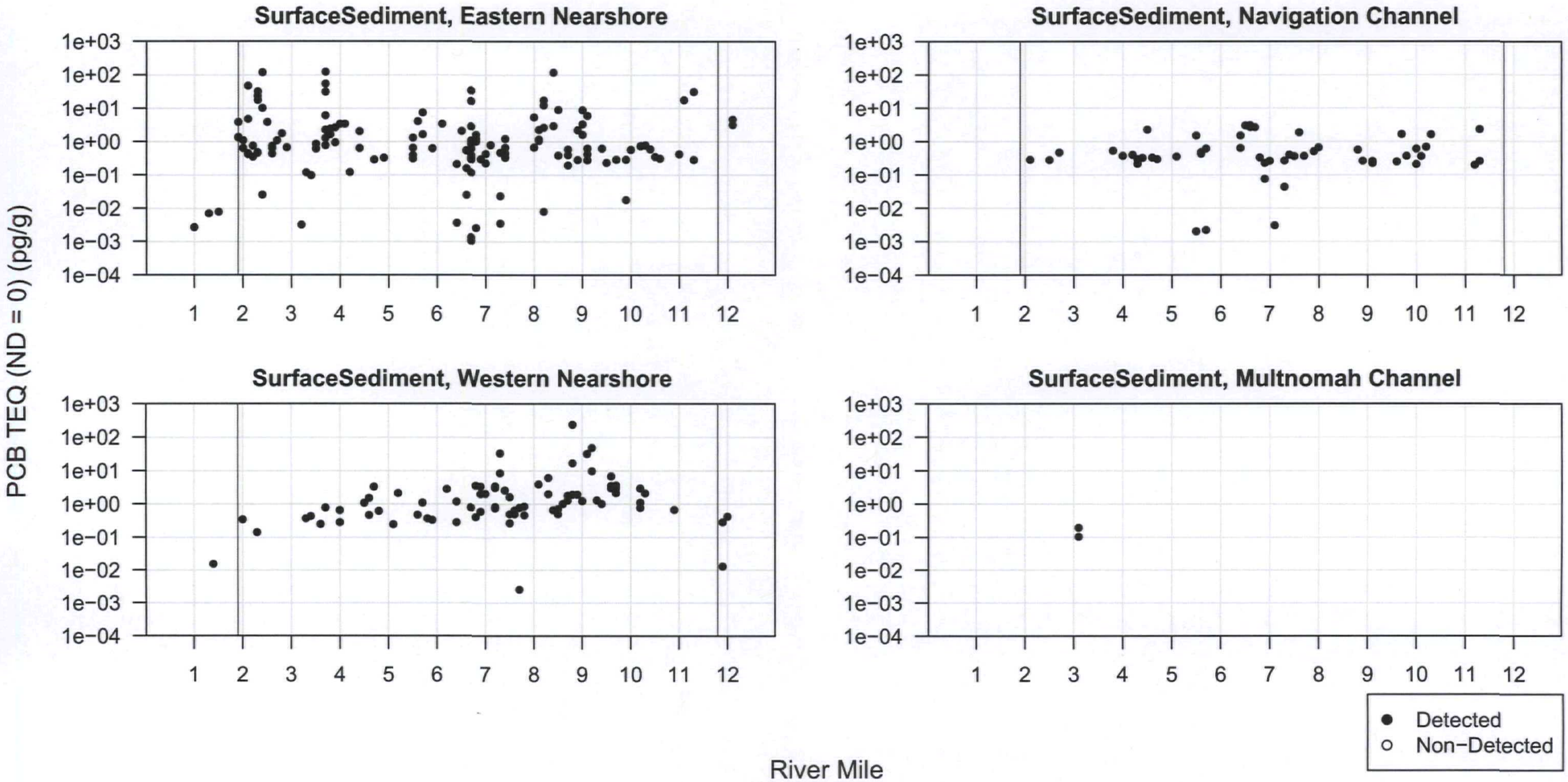

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Figure D1.3-1
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Draft Remedial Investigation Report
Scatter Plot of PCB TEQ (ND = 0)
Concentrations in Surface Sediment, RM 0.8-12.2

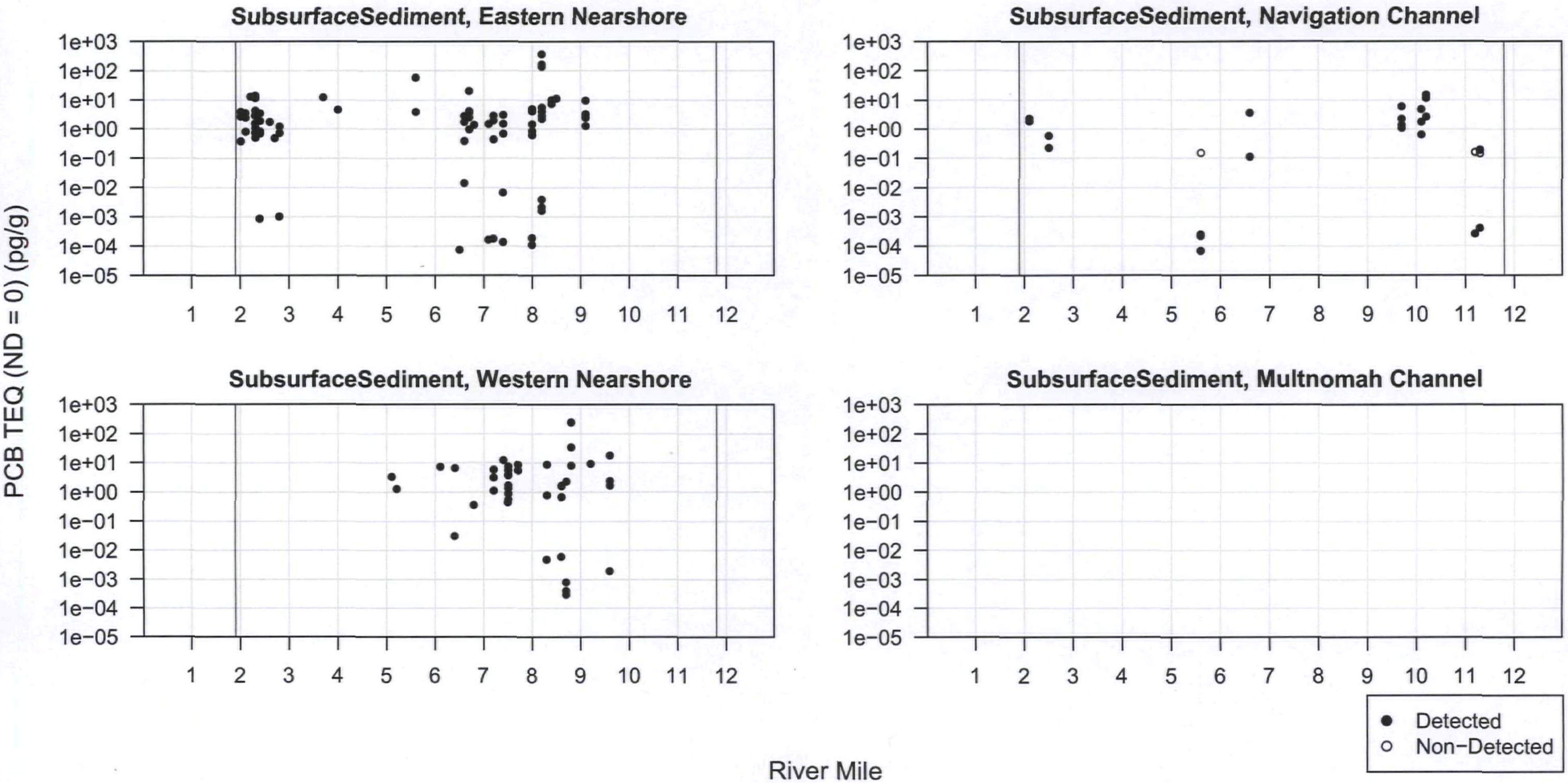

Figure D1.3-2
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of PCB TEQ (ND = 0)
Concentrations in Subsurface Sediment, RM 0.8-12.2

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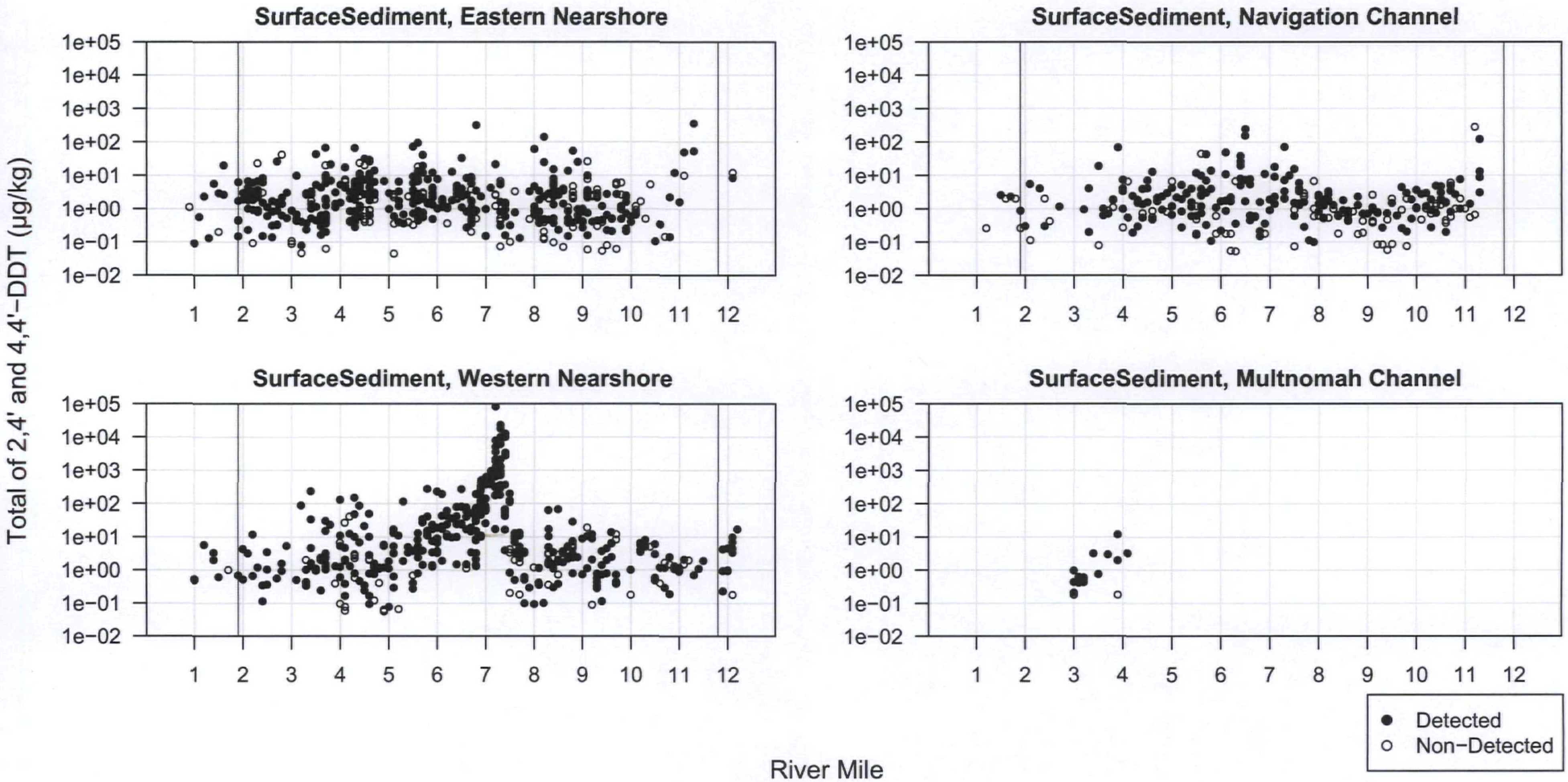

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Figure D1.3-3
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'−DDT Concentrations in Surface Sediment, RM 0.8−12.2

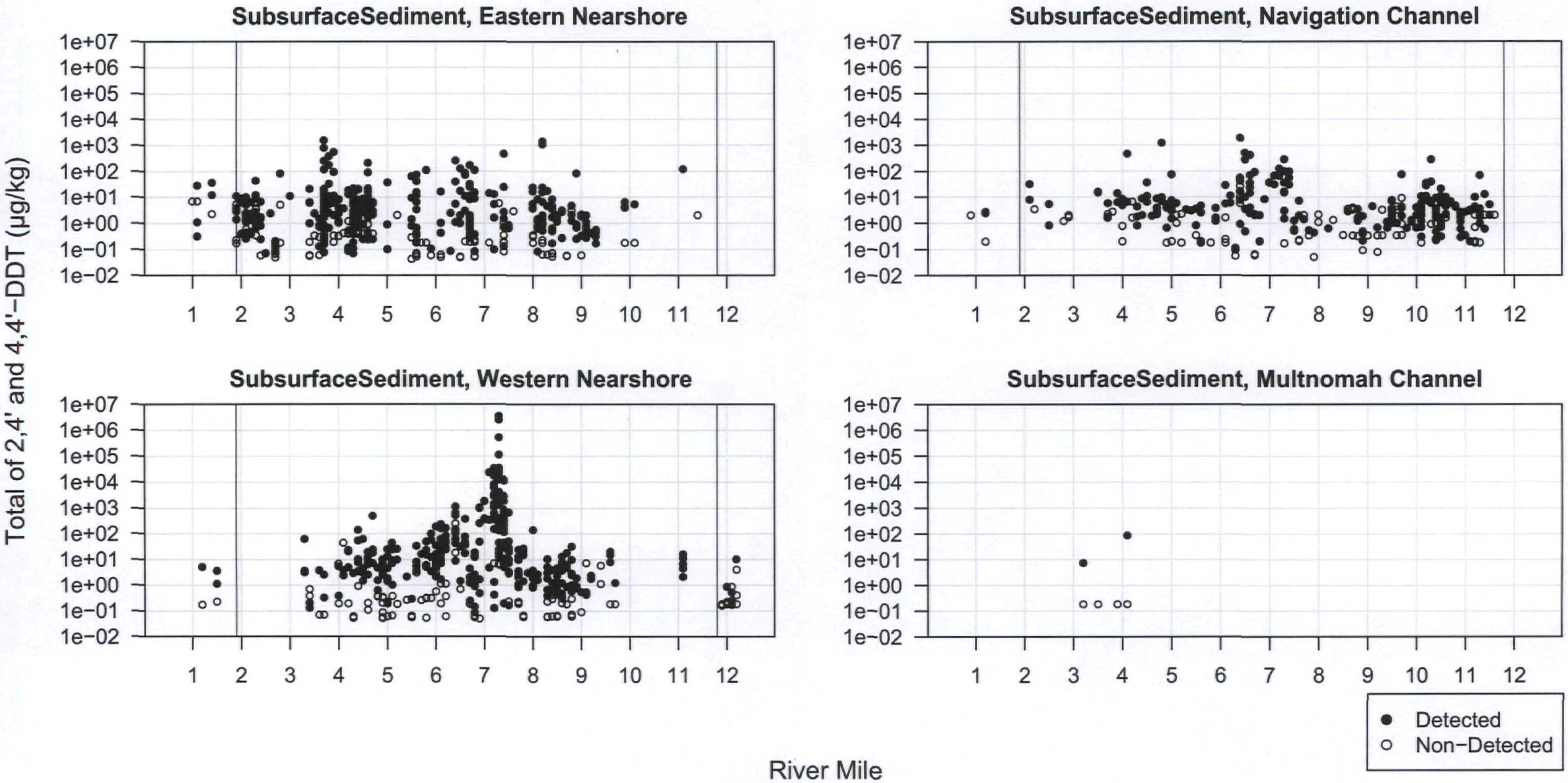

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Figure D1.3-4
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDT Concentrations in Subsurface Sediment, RM 0.8-12.2

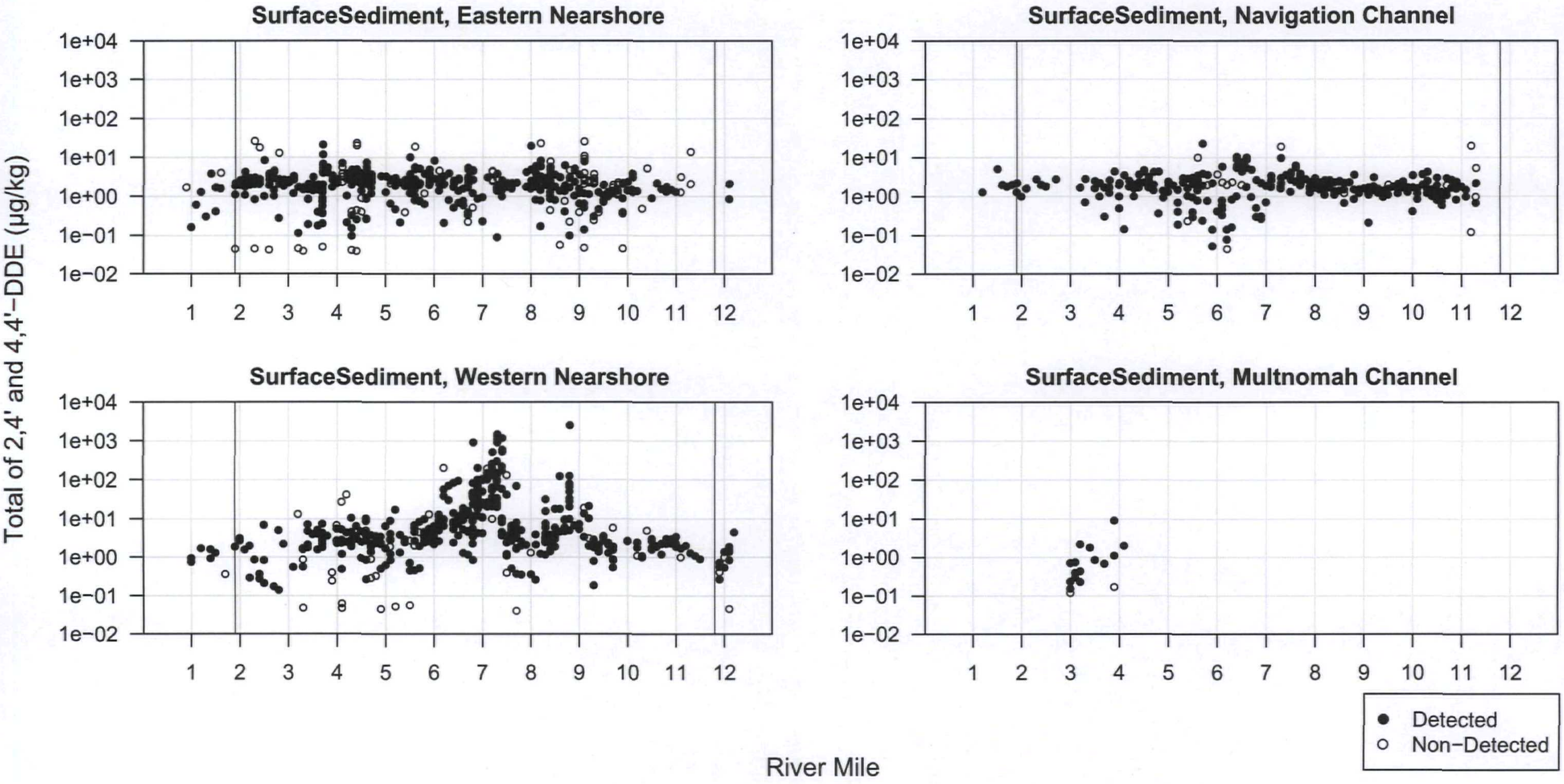

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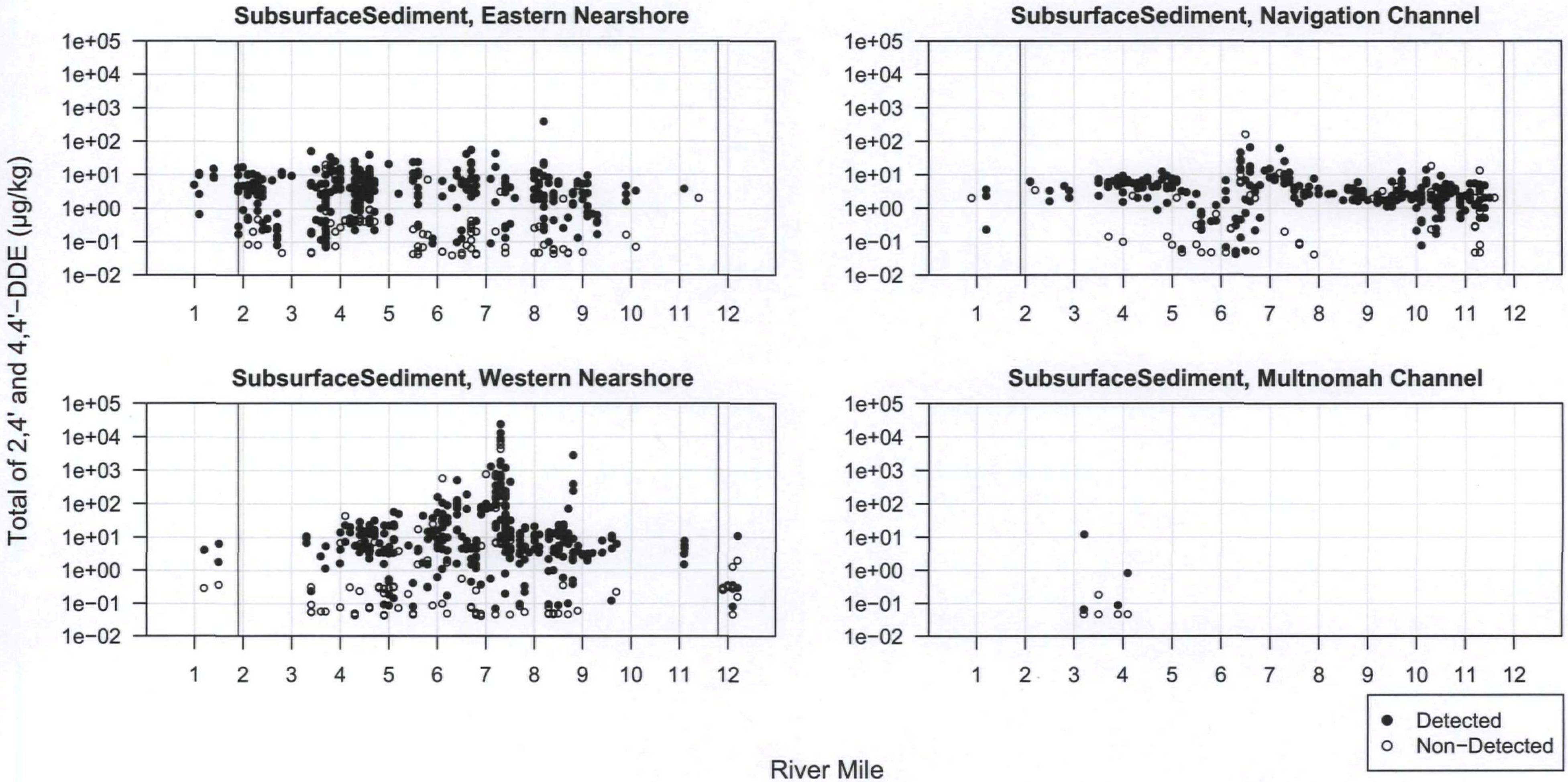
Figure D1.3−5
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'−DDE Concentrations in Surface Sediment, RM 0.8−12.2



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Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDE
Concentrations in Subsurface Sediment, RM 0.8-12.2

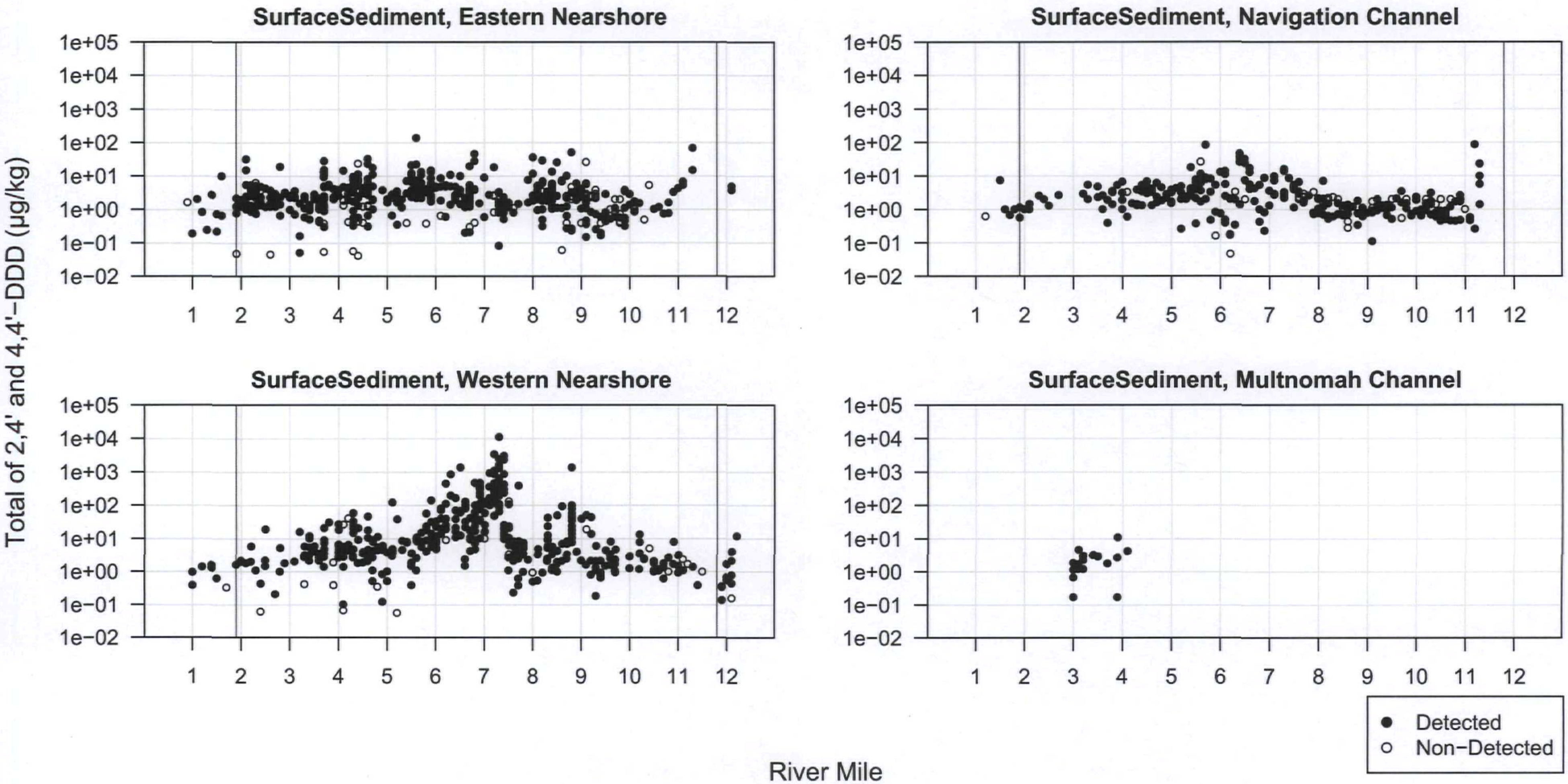

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Figure D1.3−7

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Draft Remedial Investigation Report

Scatter Plot of Total of 2,4' and 4,4'−DDD Concentrations in Surface Sediment, RM 0.8−12.2

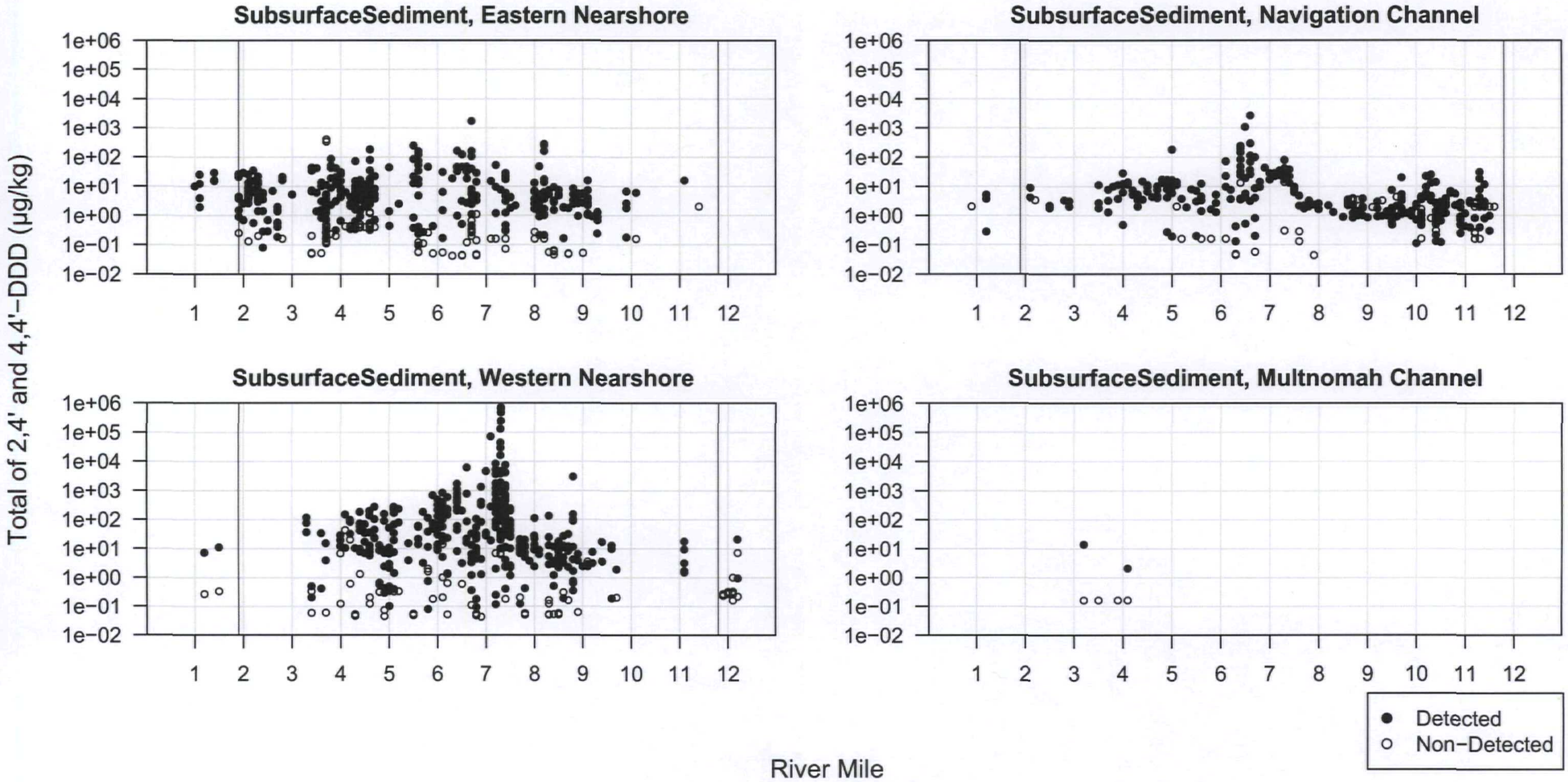

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Figure D1.3−8
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Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'−DDD
Concentrations in Subsurface Sediment, RM 0.8−12.2

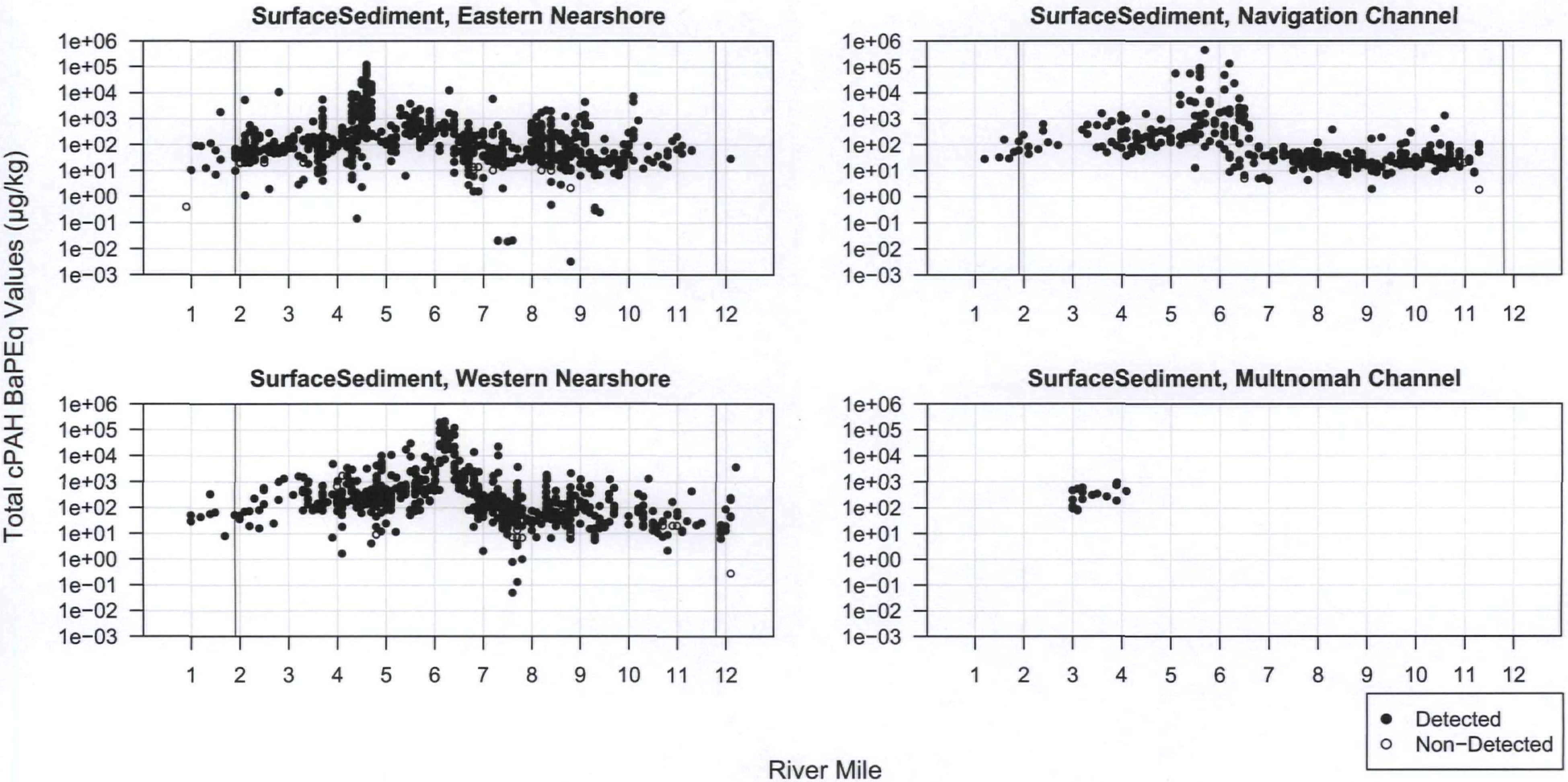

Figure D1.3-9
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total cPAH BaPEq
Concentrations in Surface Sediment, RM 0.8–12.2

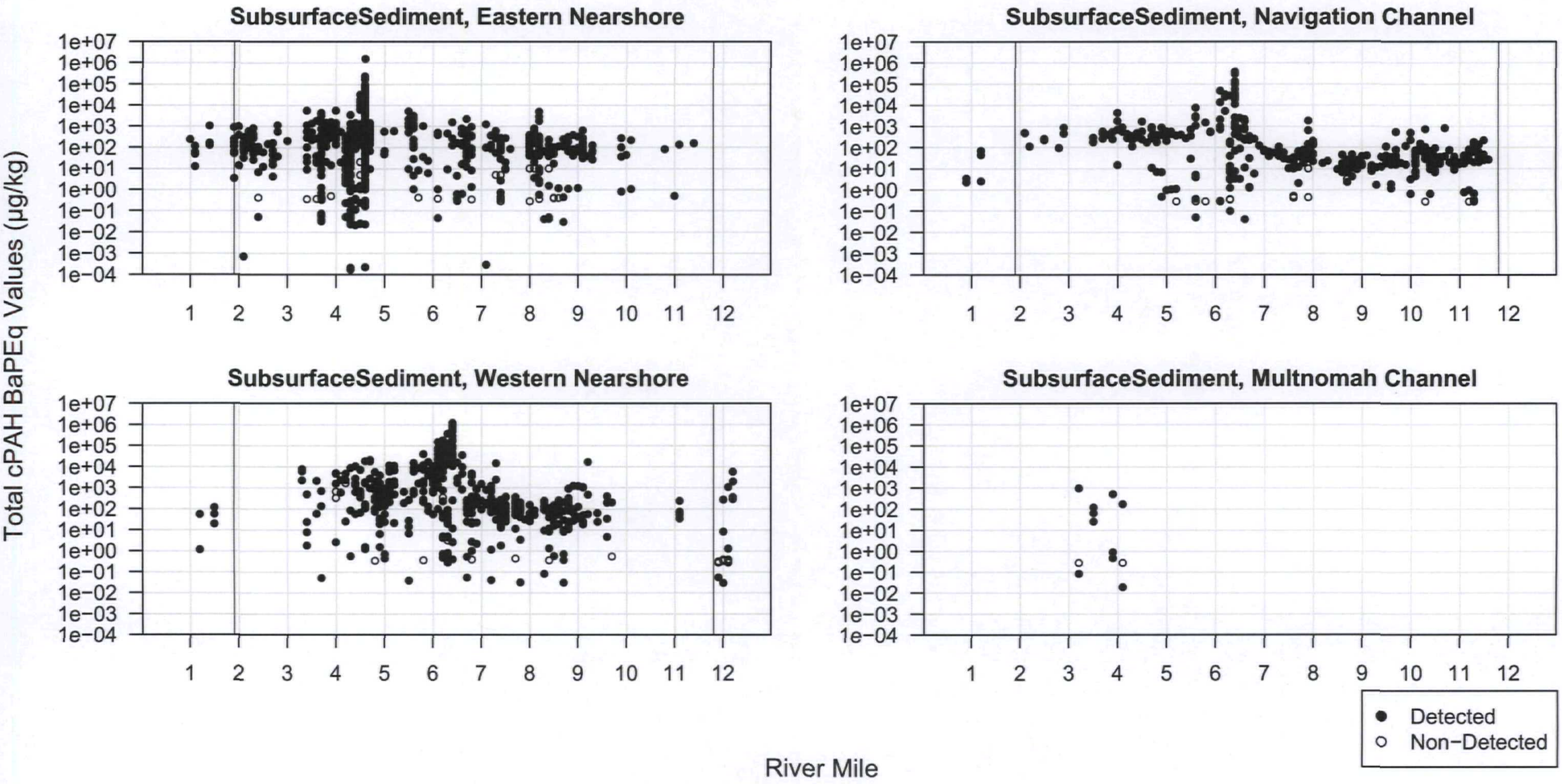

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Figure D1.3−10
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total cPAH BaPEq Concentrations in Subsurface Sediment, RM 0.8−12.2

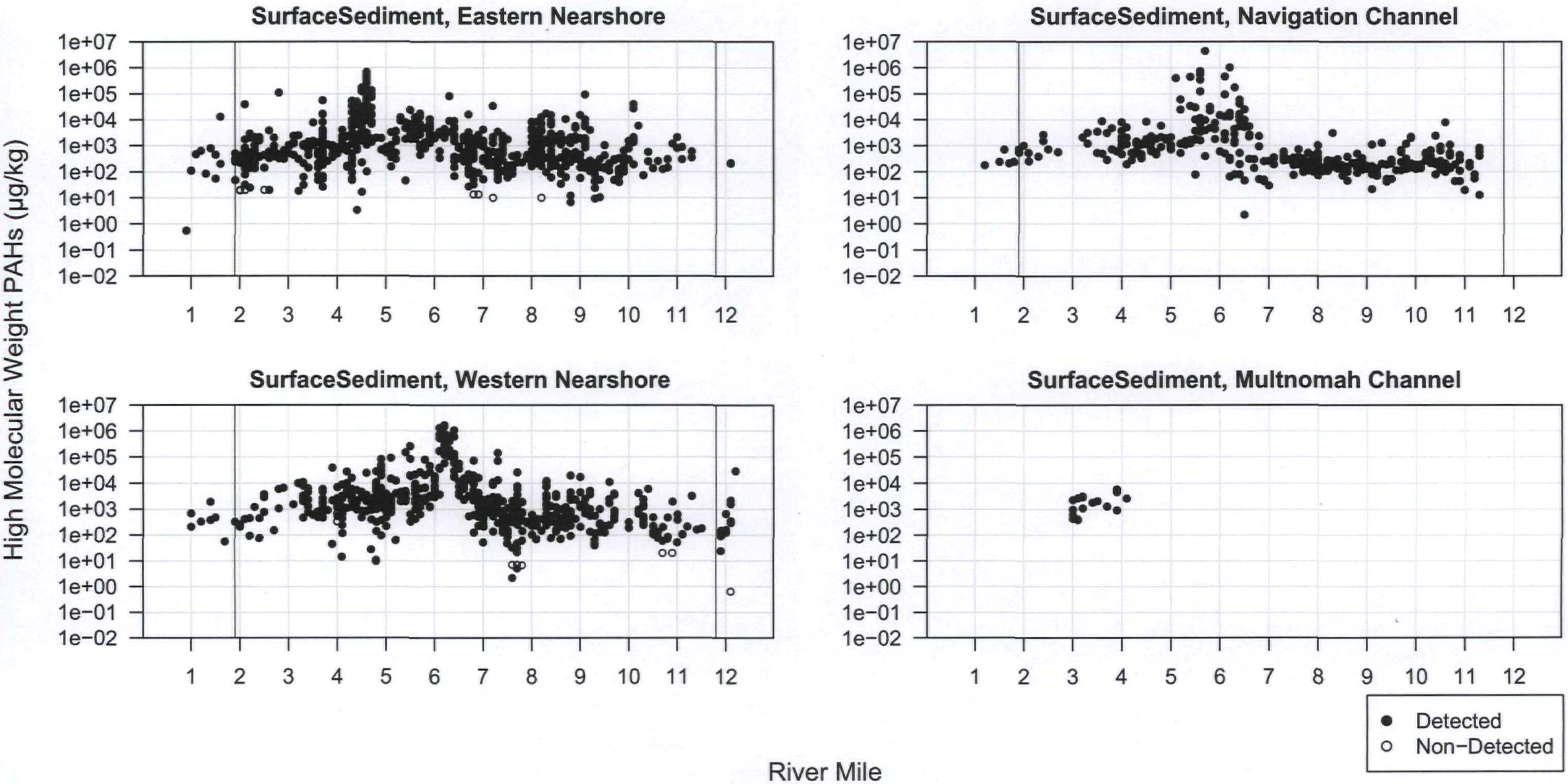

Figure D1.3−11
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of High Molecular Weight PAH
Concentrations in Surface Sediment, RM 0.8−12.2

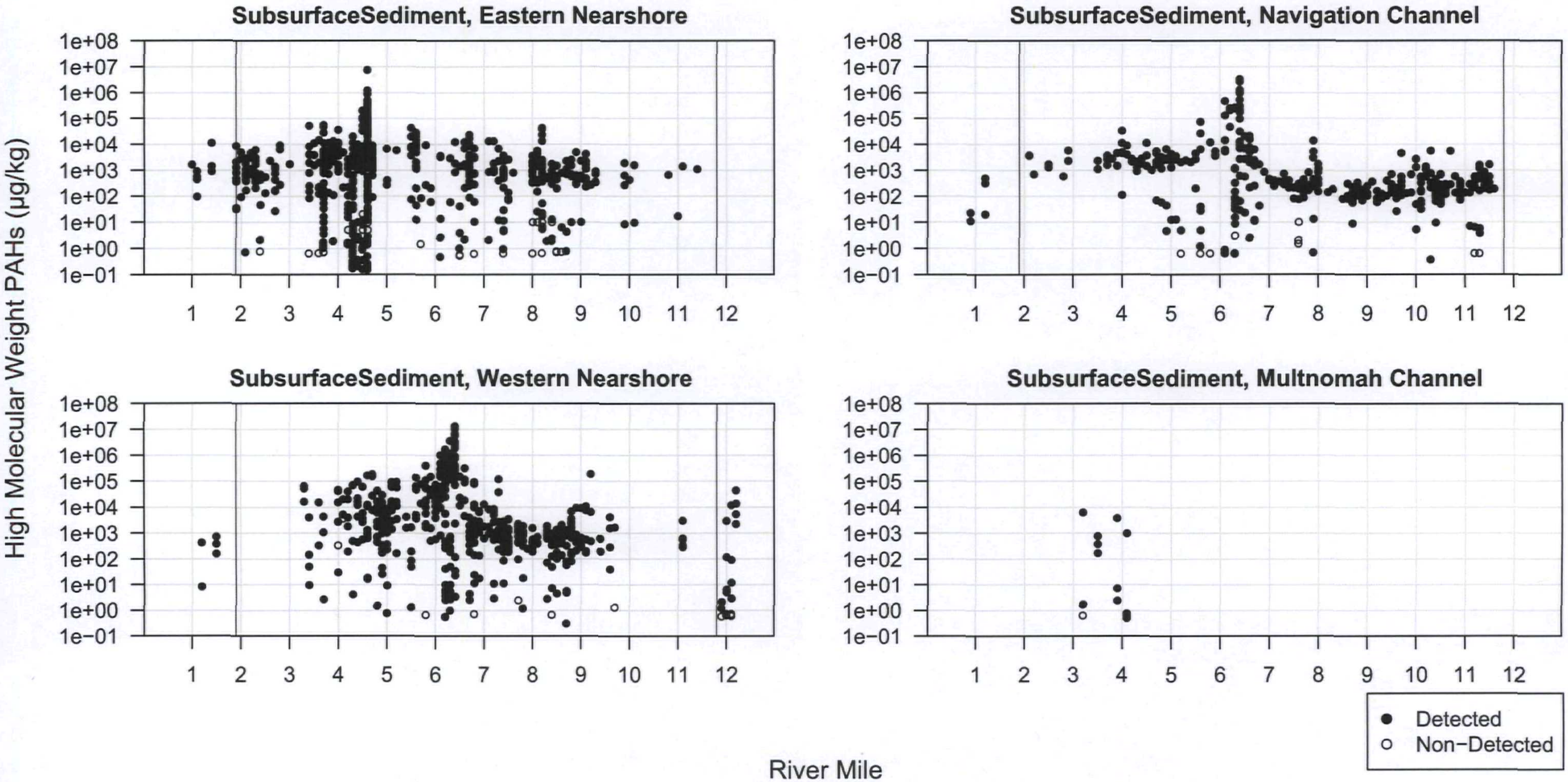

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Figure D1.3−12
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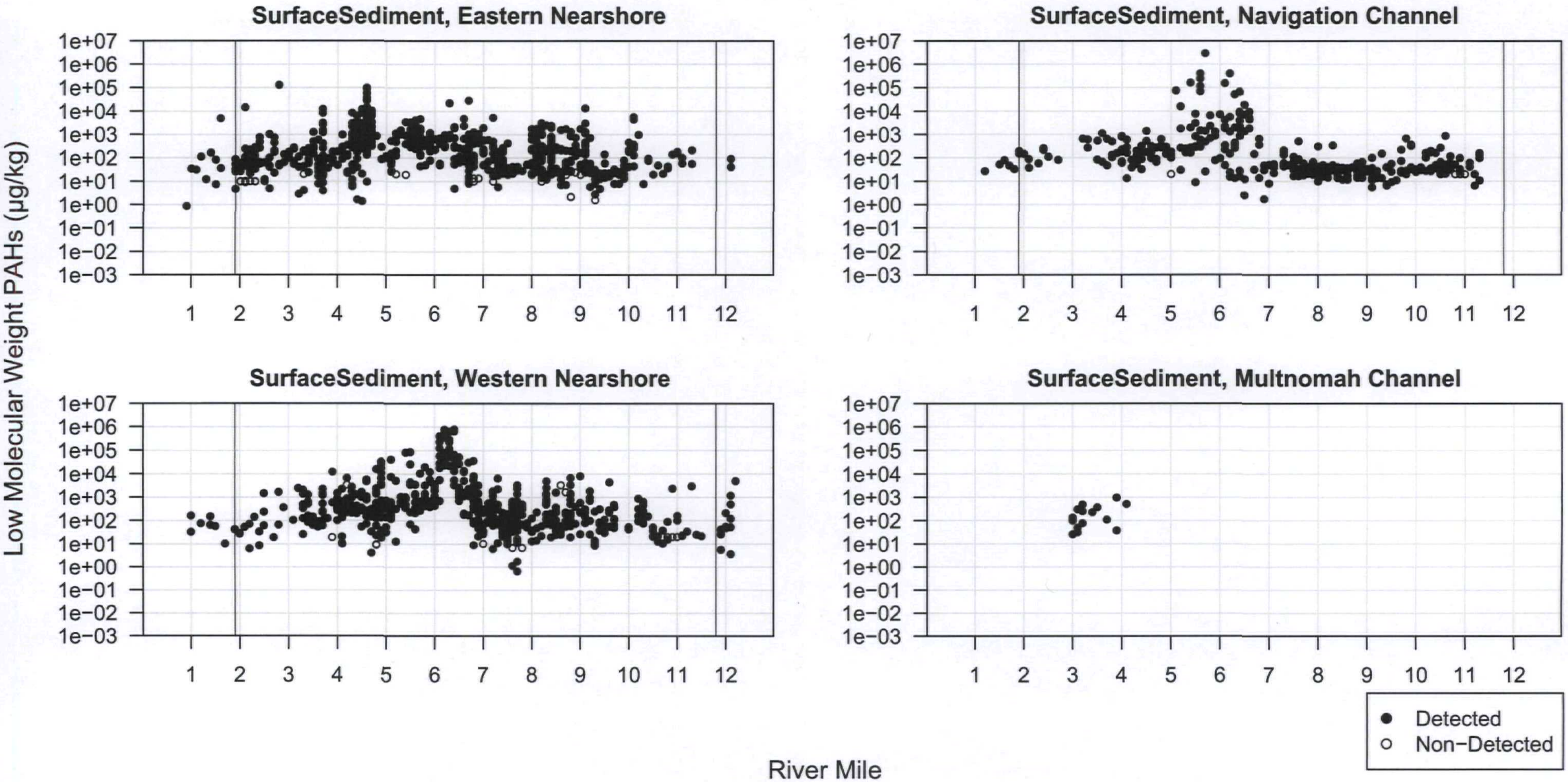
Draft Remedial Investigation Report
Scatter Plot of High Molecular Weight PAH Concentrations in Subsurface Sediment, RM 0.8−12.2



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Scatter Plot of Low Molecular Weight PAH Concentrations in Surface Sediment, RM 0.8-12.2

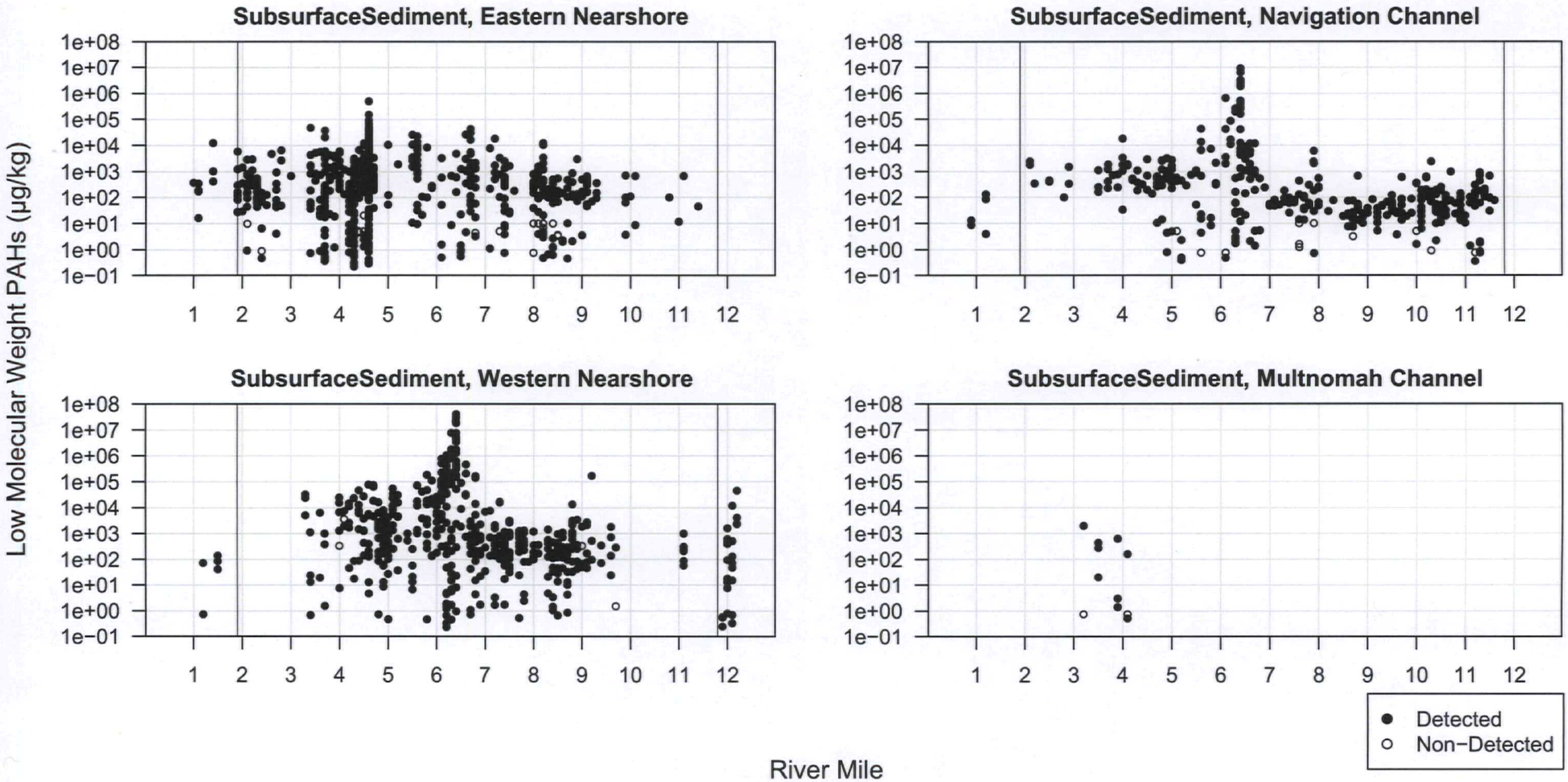

Figure D1.3-14
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Low Molecular Weight PAH Concentrations in Subsurface Sediment, RM 0.8-12.2

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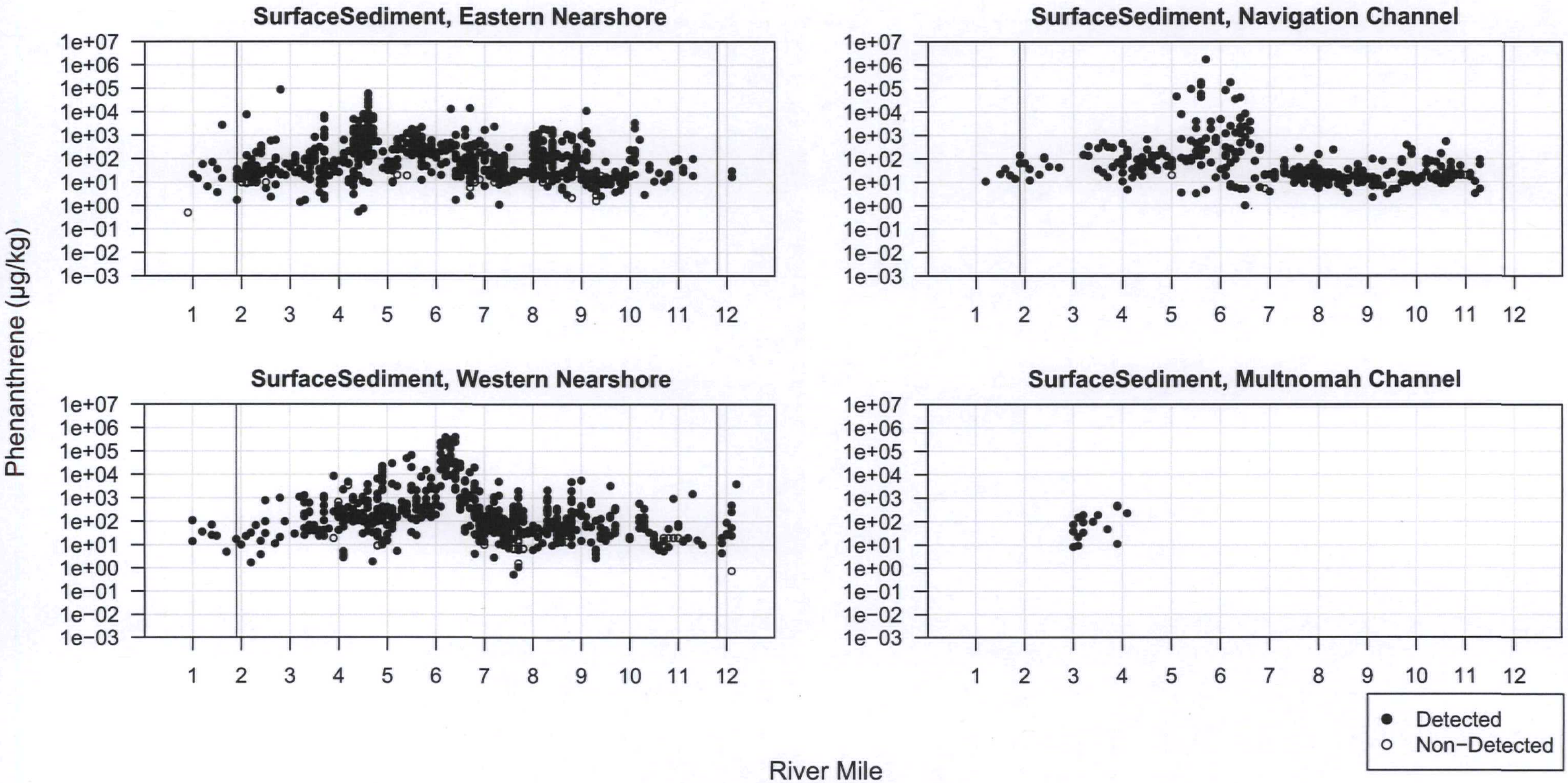

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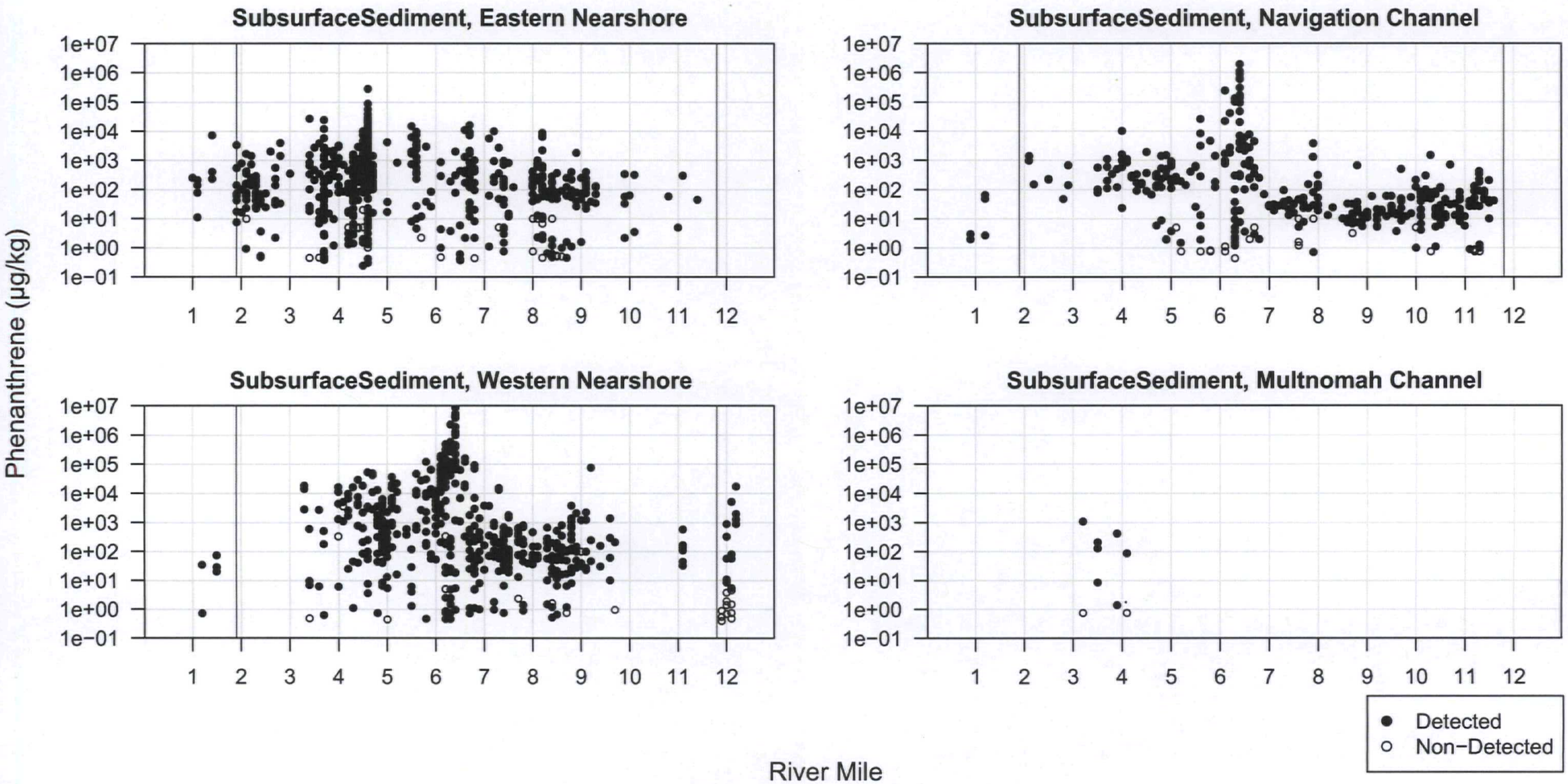
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Phenanthrene
Concentrations in Surface Sediment, RM 0.8−12.2



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Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Phenanthrene
Concentrations in Subsurface Sediment, RM 0.8−12.2

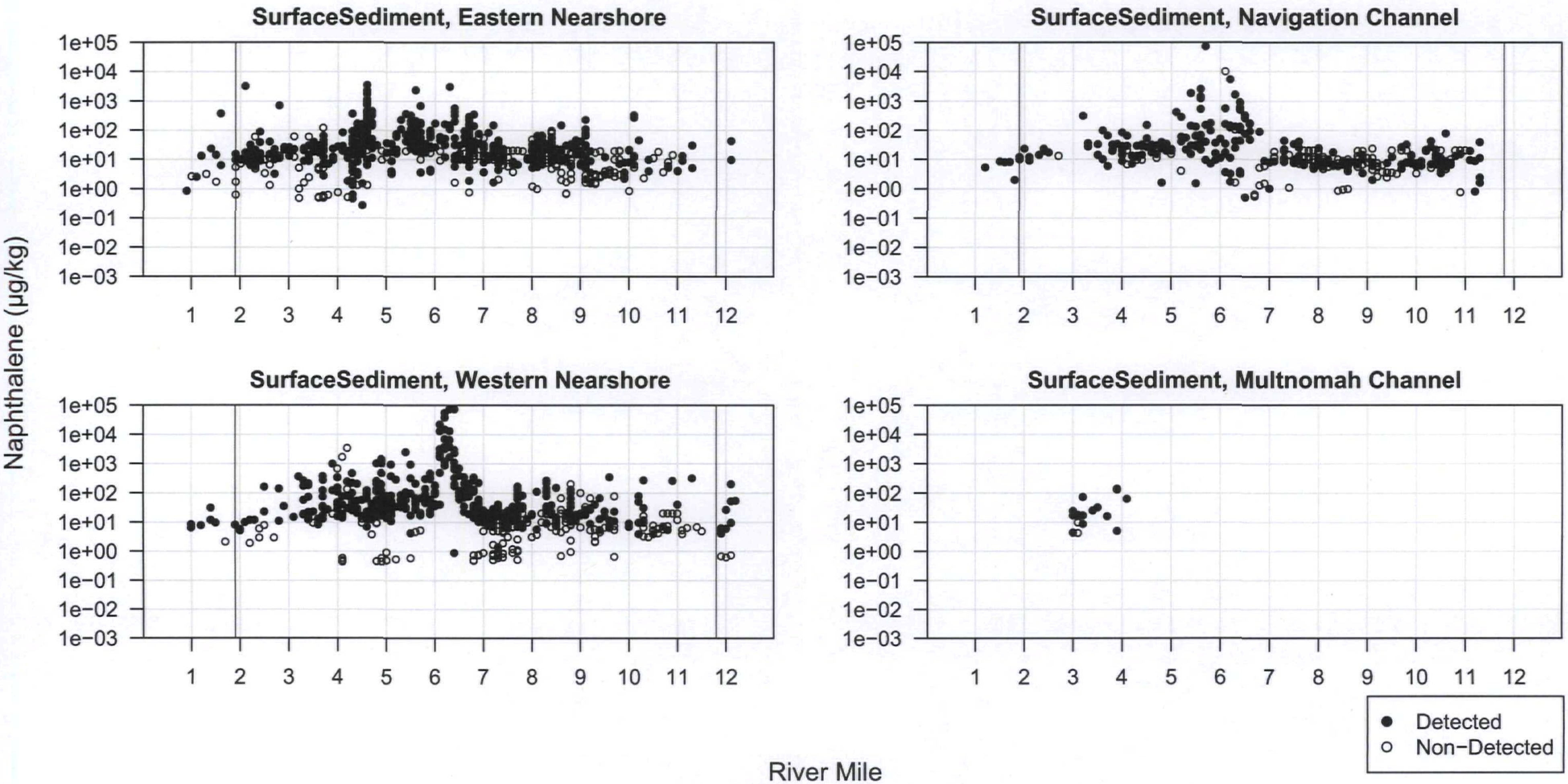

Figure D1.3−17
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Naphthalene
Concentrations in Surface Sediment, RM 0.8−12.2

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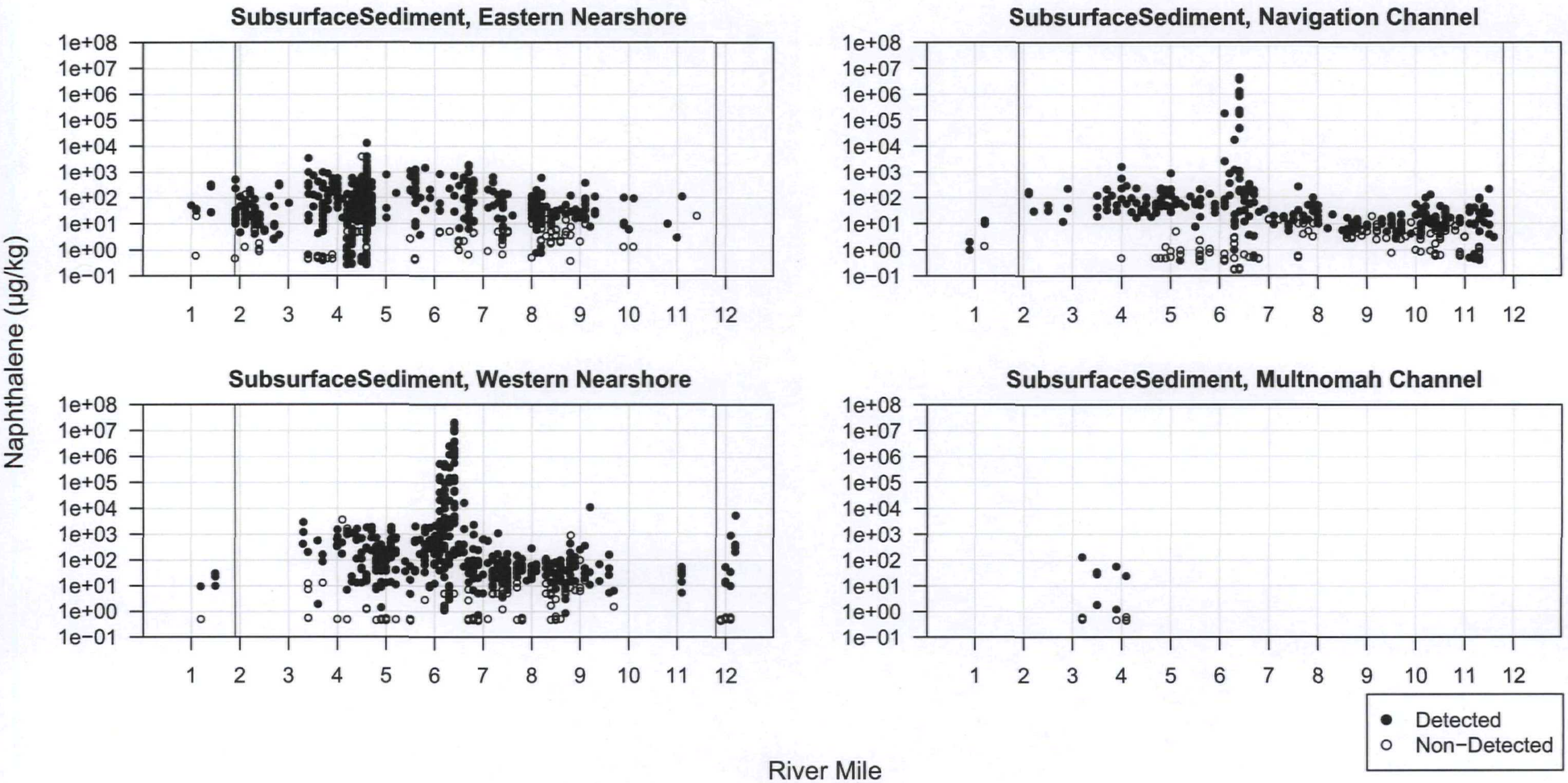

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Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Naphthalene
Concentrations in Subsurface Sediment, RM 0.8−12.2

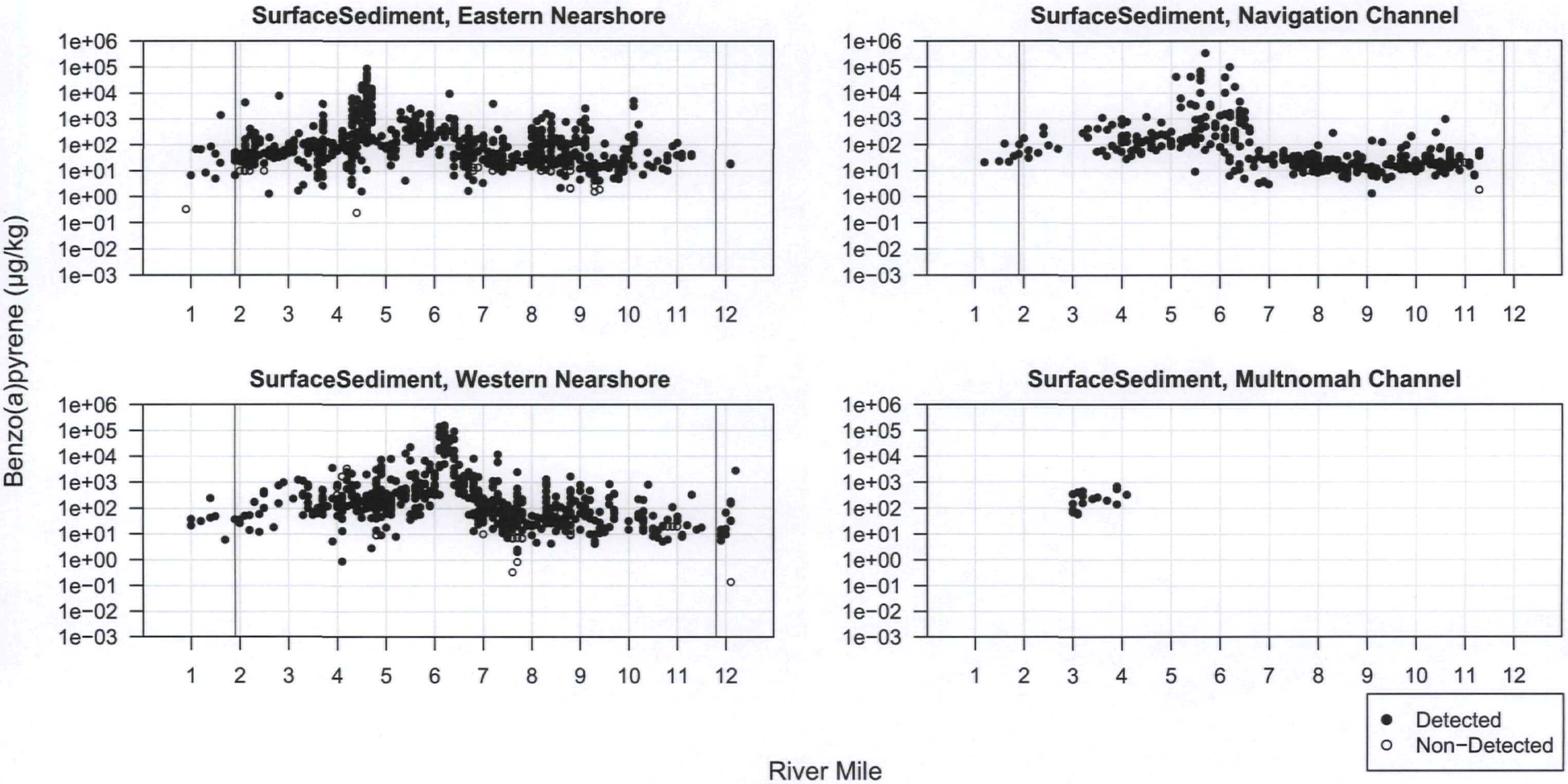

Figure D1.3-19
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Benzo(a)pyrene
Concentrations in Surface Sediment, RM 0.8-12.2

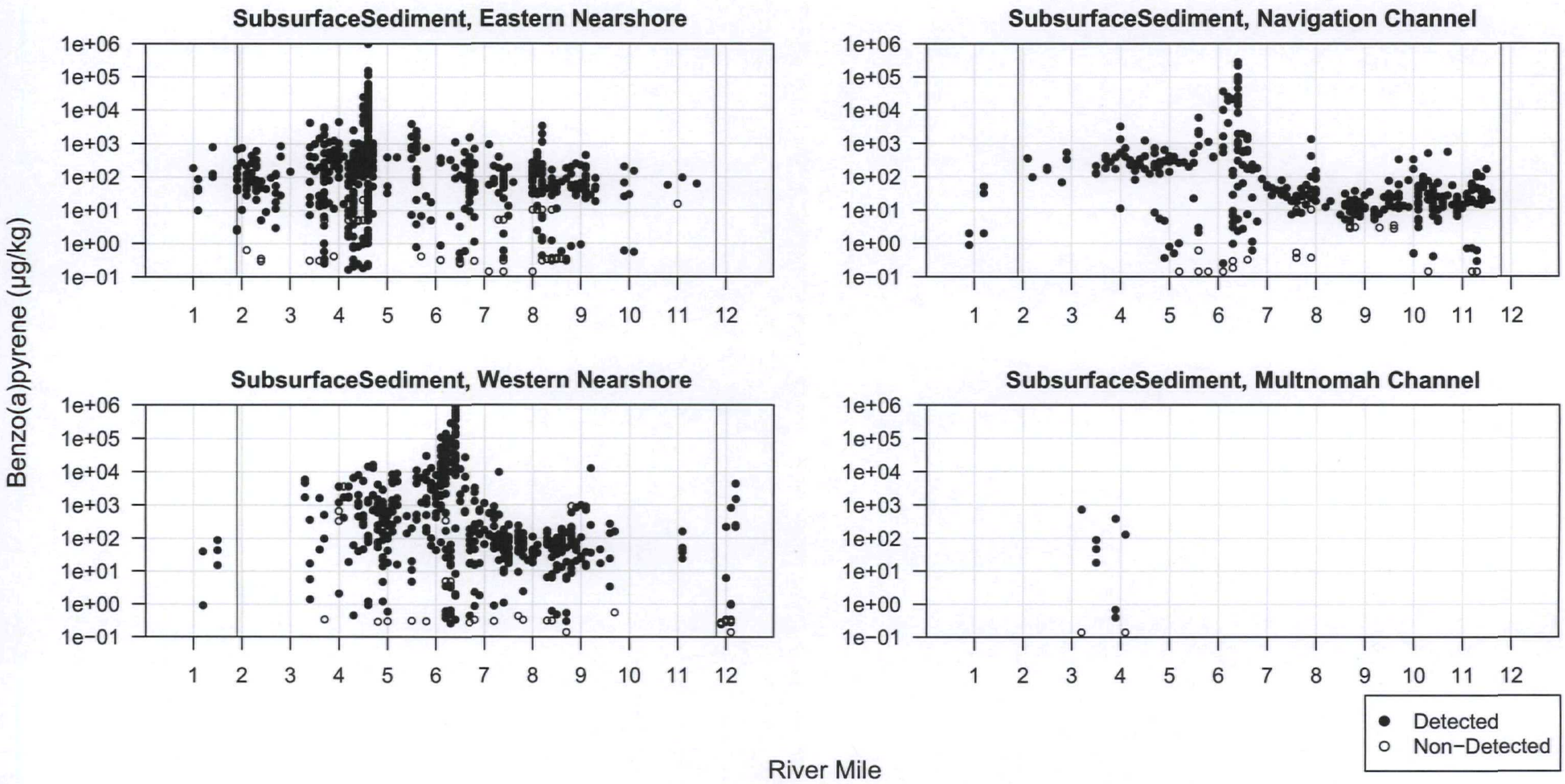

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Figure D1.3-20
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Benzo(a)pyrene
Concentrations in Subsurface Sediment, RM 0.8-12.2

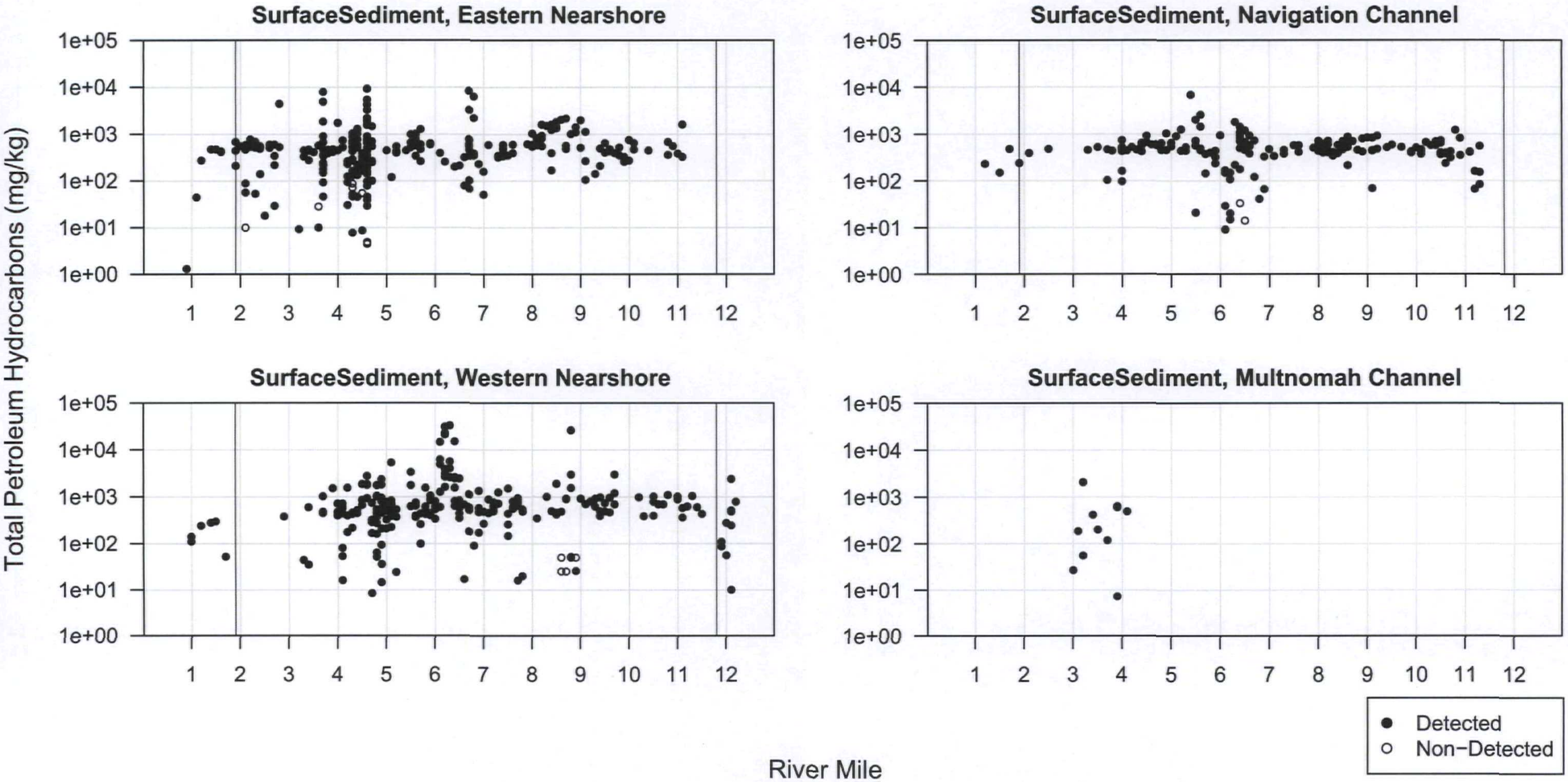

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Figure D1.3−21
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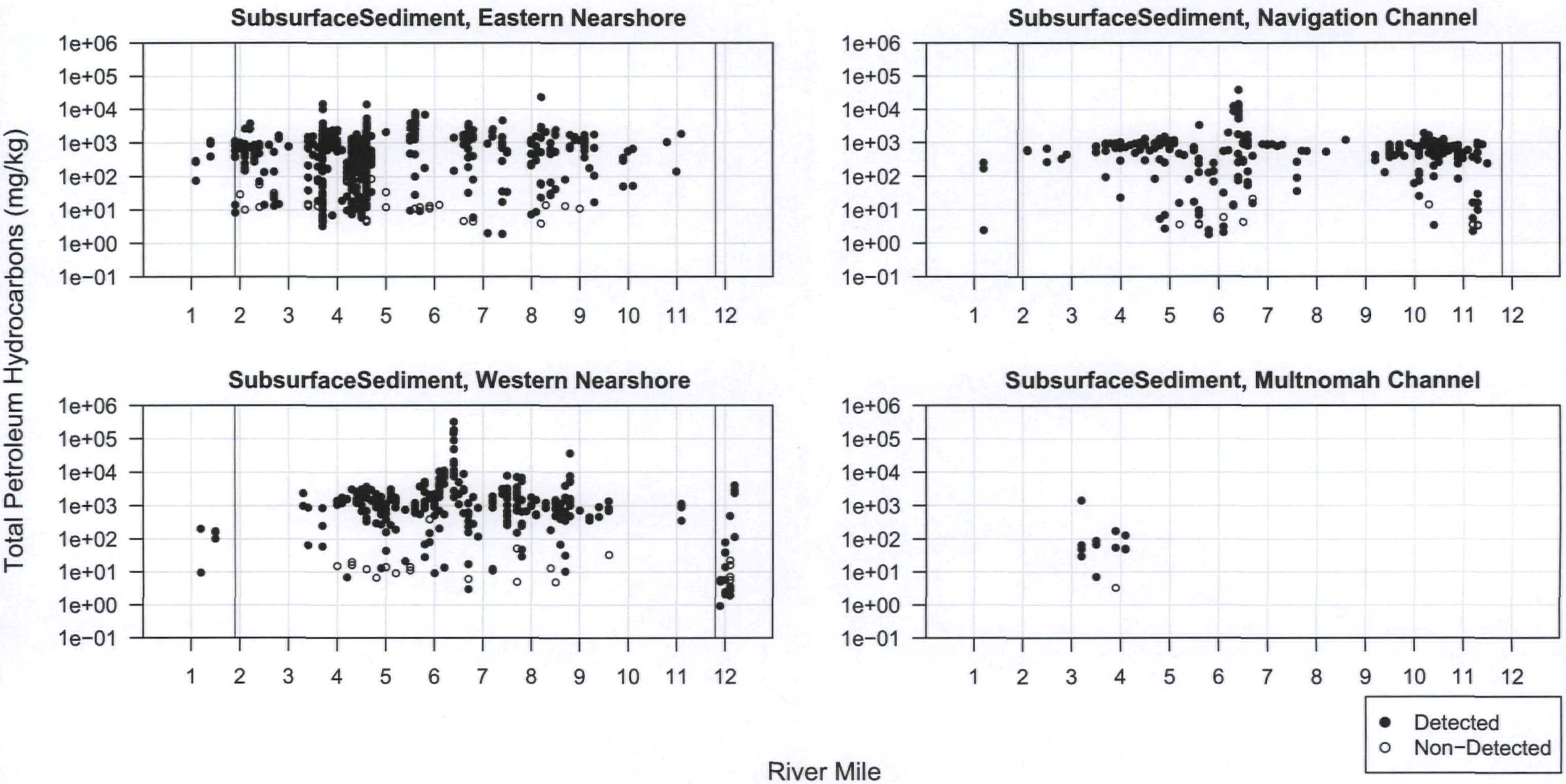
Draft Remedial Investigation Report
Scatter Plot of Total Petroleum Hydrocarbon Concentrations in Surface Sediment, RM 0.8−12.2



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Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total Petroleum Hydrocarbon Concentrations in Subsurface Sediment, RM 0.8−12.2

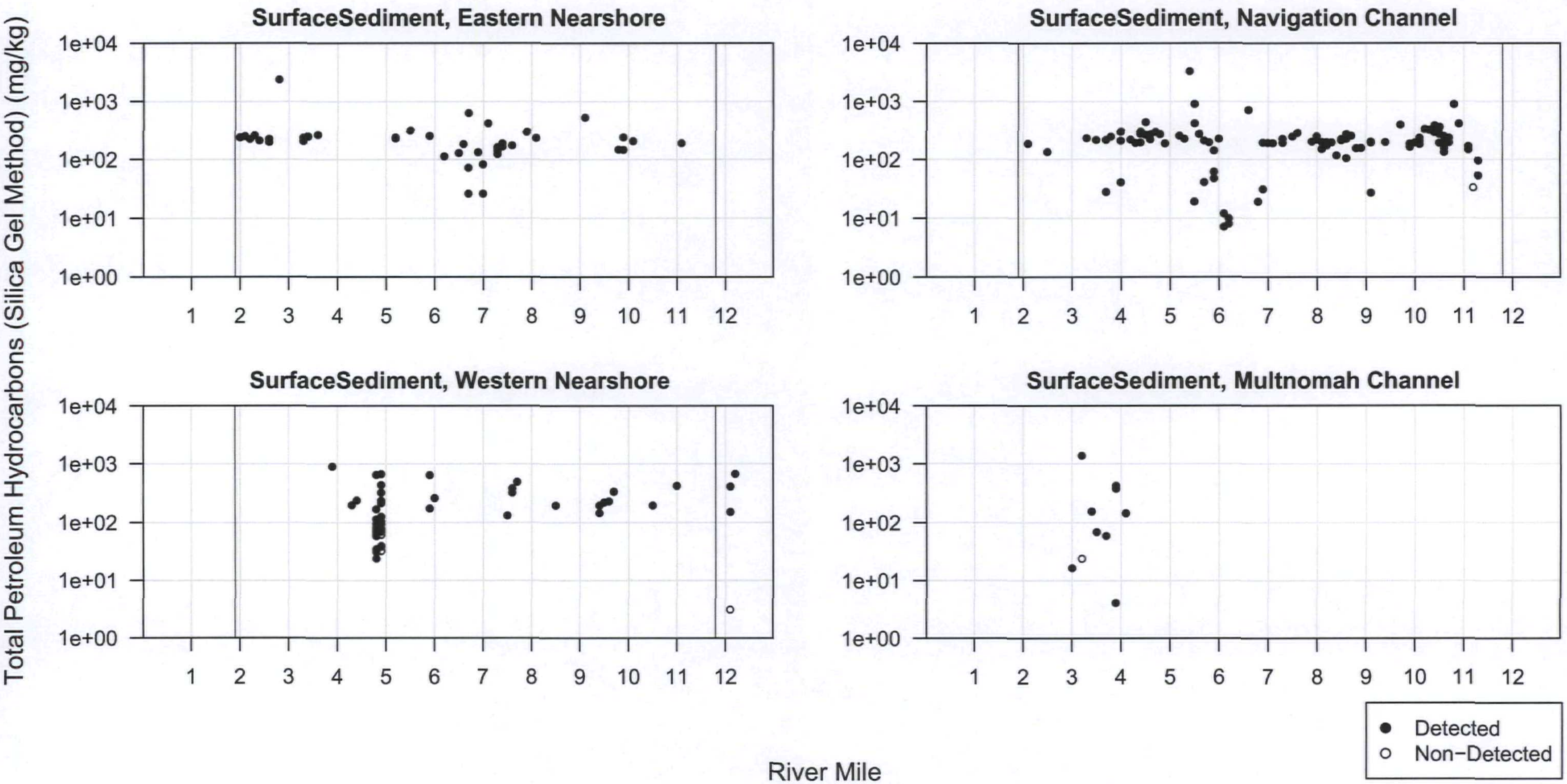
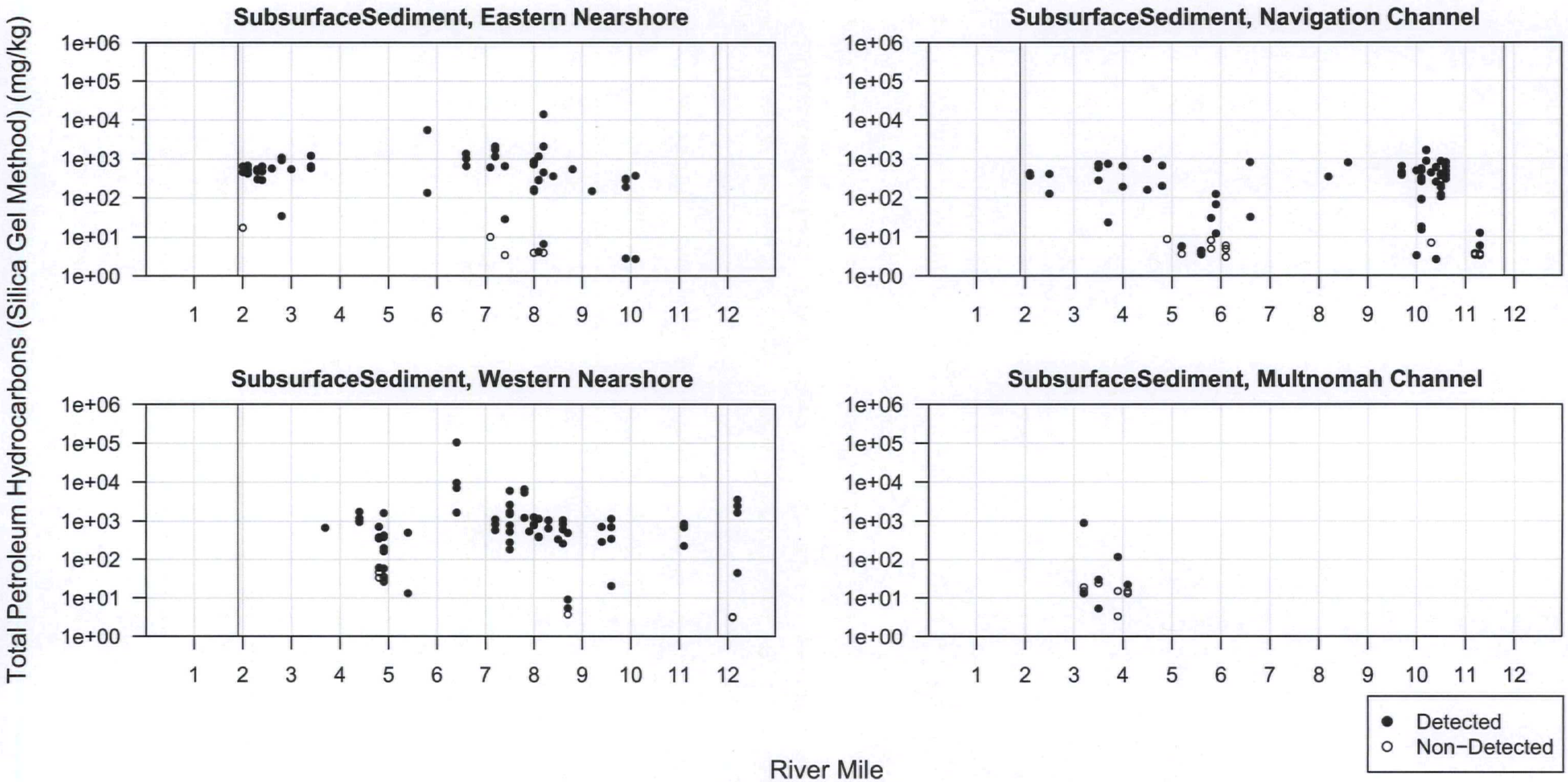


Figure D1.3−23
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total Petroleum Hydrocarbon (Silica Gel Method) Concentrations in Surface Sediment, RM 0.8−12.2



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Portland Harbor RI/FS
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Scatter Plot of Total Petroleum Hydrocarbon (Silica Gel Method)
Concentrations in Subsurface Sediment, RM 0.8−12.2

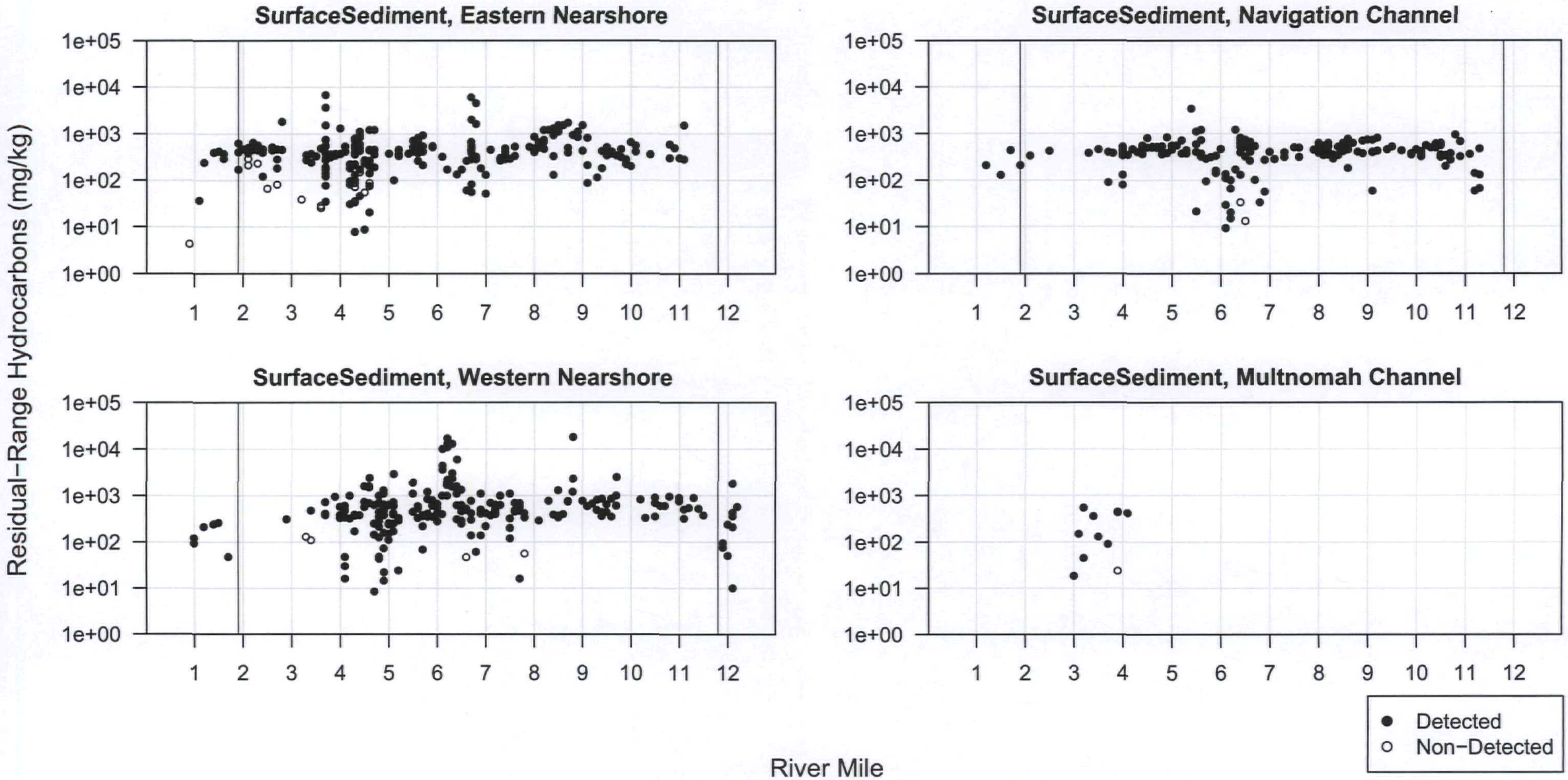

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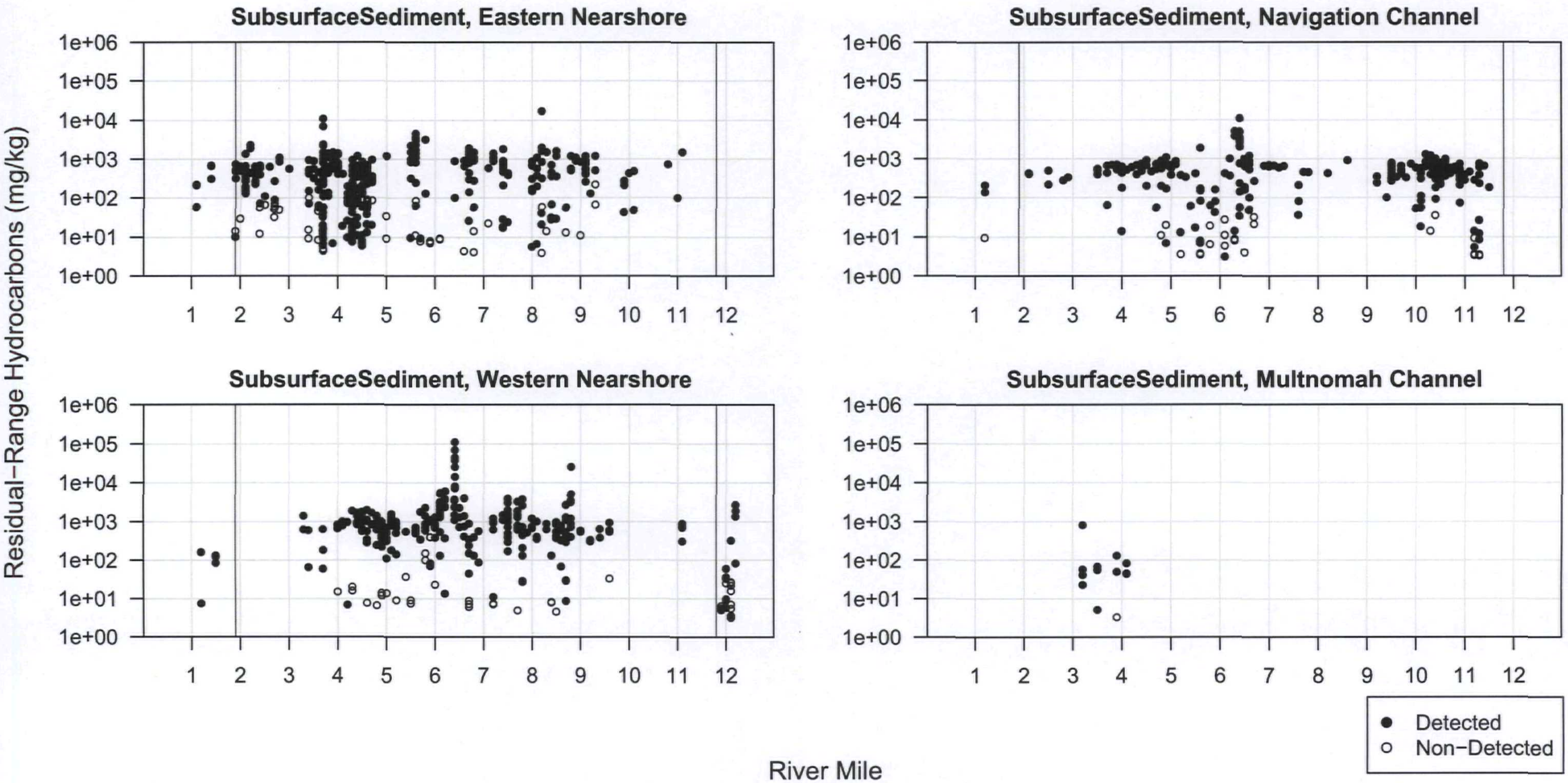
Figure D1.3-25
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Residual-Range Hydrocarbon Concentrations in Surface Sediment, RM 0.8-12.2



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Draft Remedial Investigation Report
Scatter Plot of Residual−Range Hydrocarbon Concentrations in Subsurface Sediment, RM 0.8−12.2

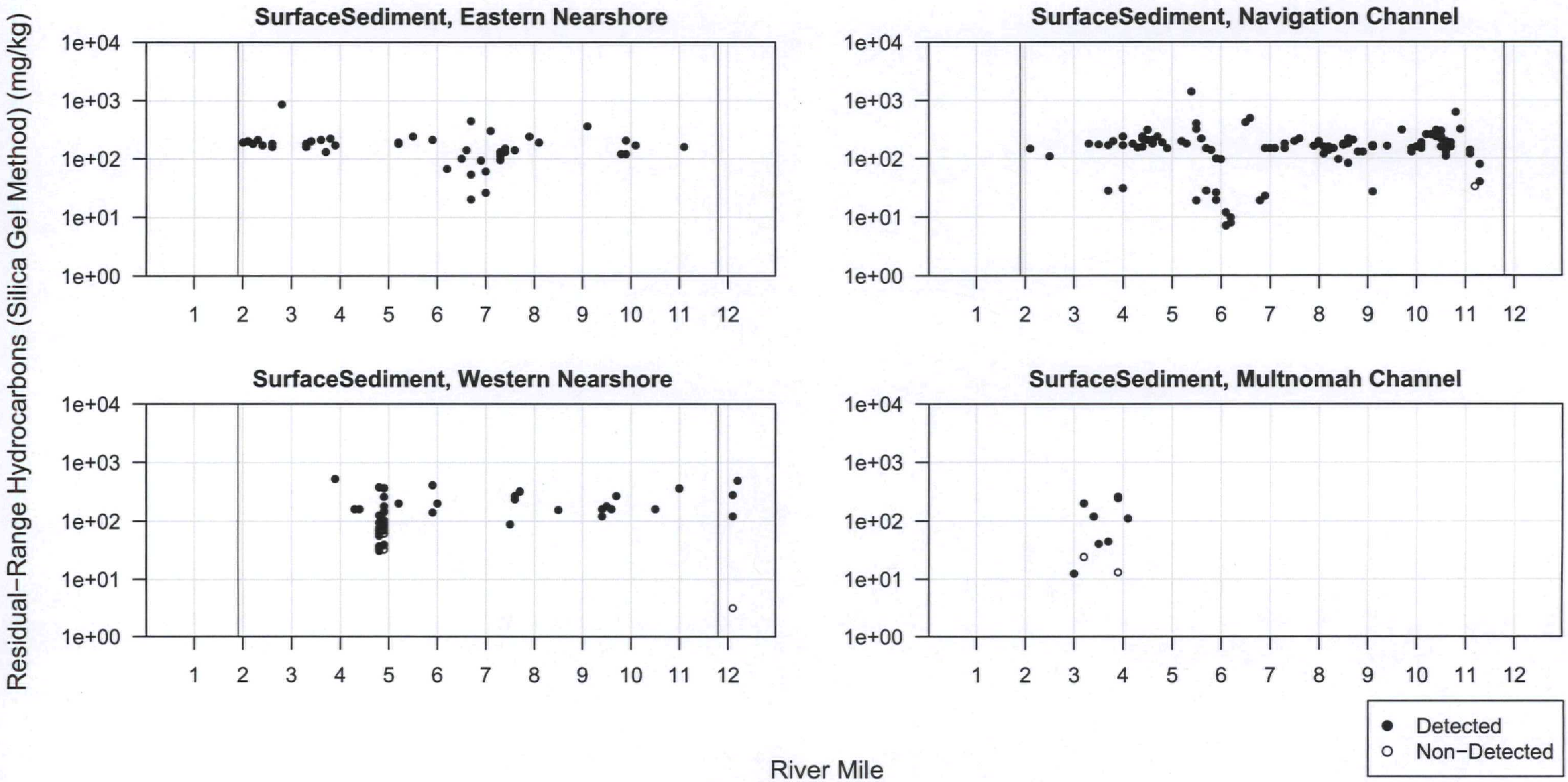

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Figure D1.3−27
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Residual−Range Hydrocarbon (Silica Gel Method)
Concentrations in Surface Sediment, RM 0.8−12.2

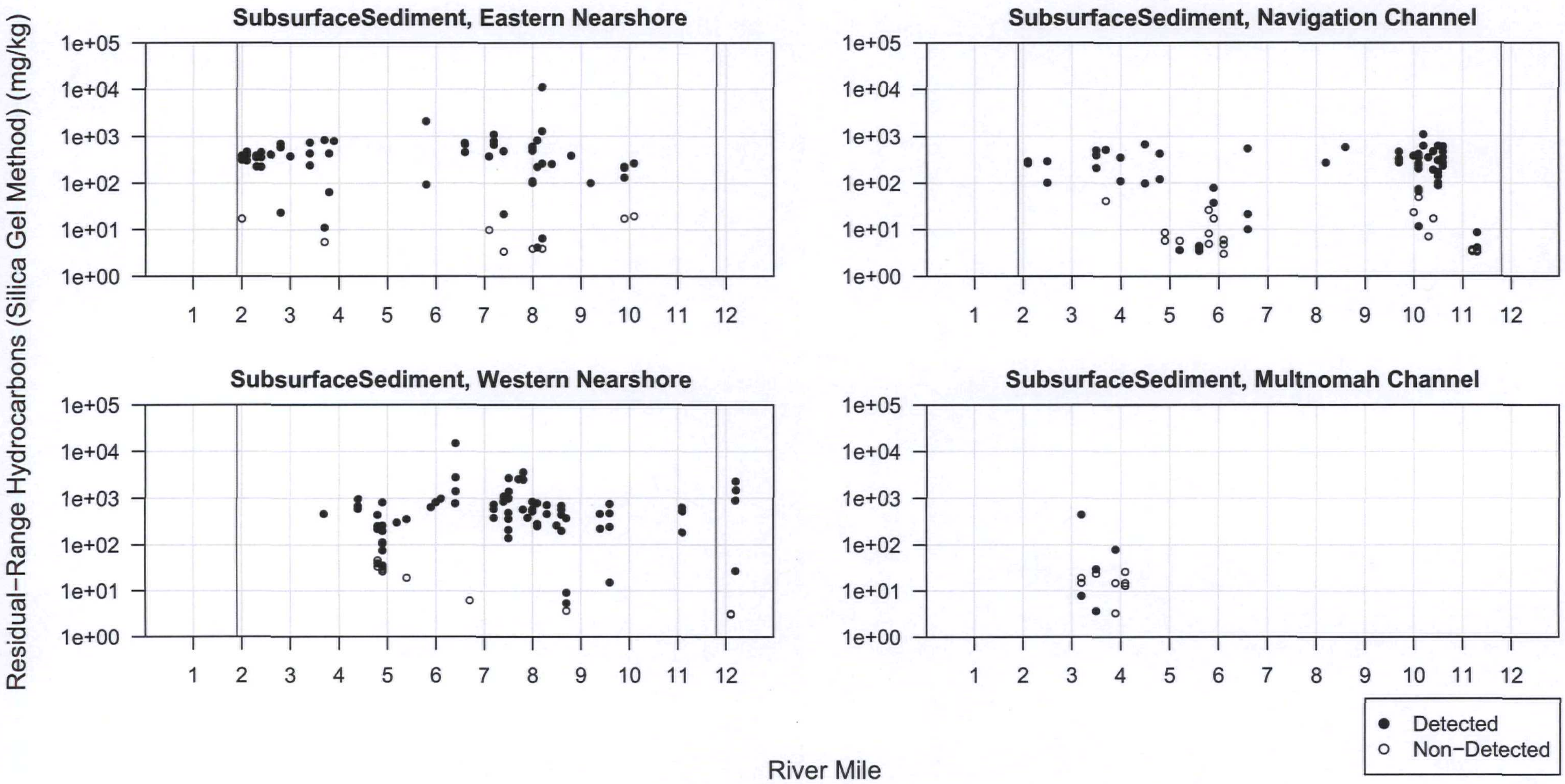

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Figure D1.3−28
Portland Harbor RI/FS
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Scatter Plot of Residual−Range Hydrocarbon (Silica Gel Method) Concentrations in Subsurface Sediment, RM 0.8−12.2

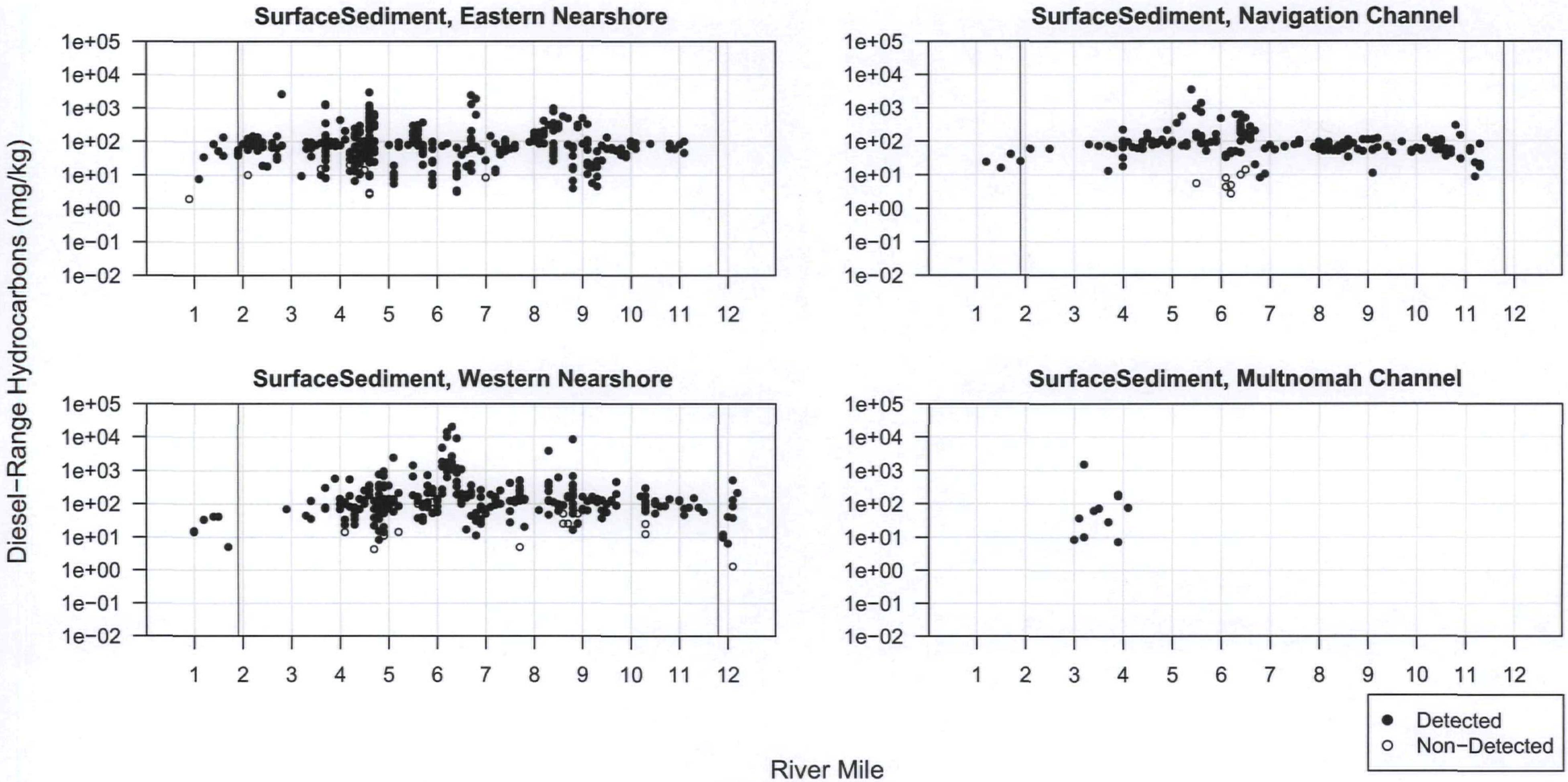

Figure D1.3-29
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Diesel-Range Hydrocarbon
Concentrations in Surface Sediment, RM 0.8-12.2

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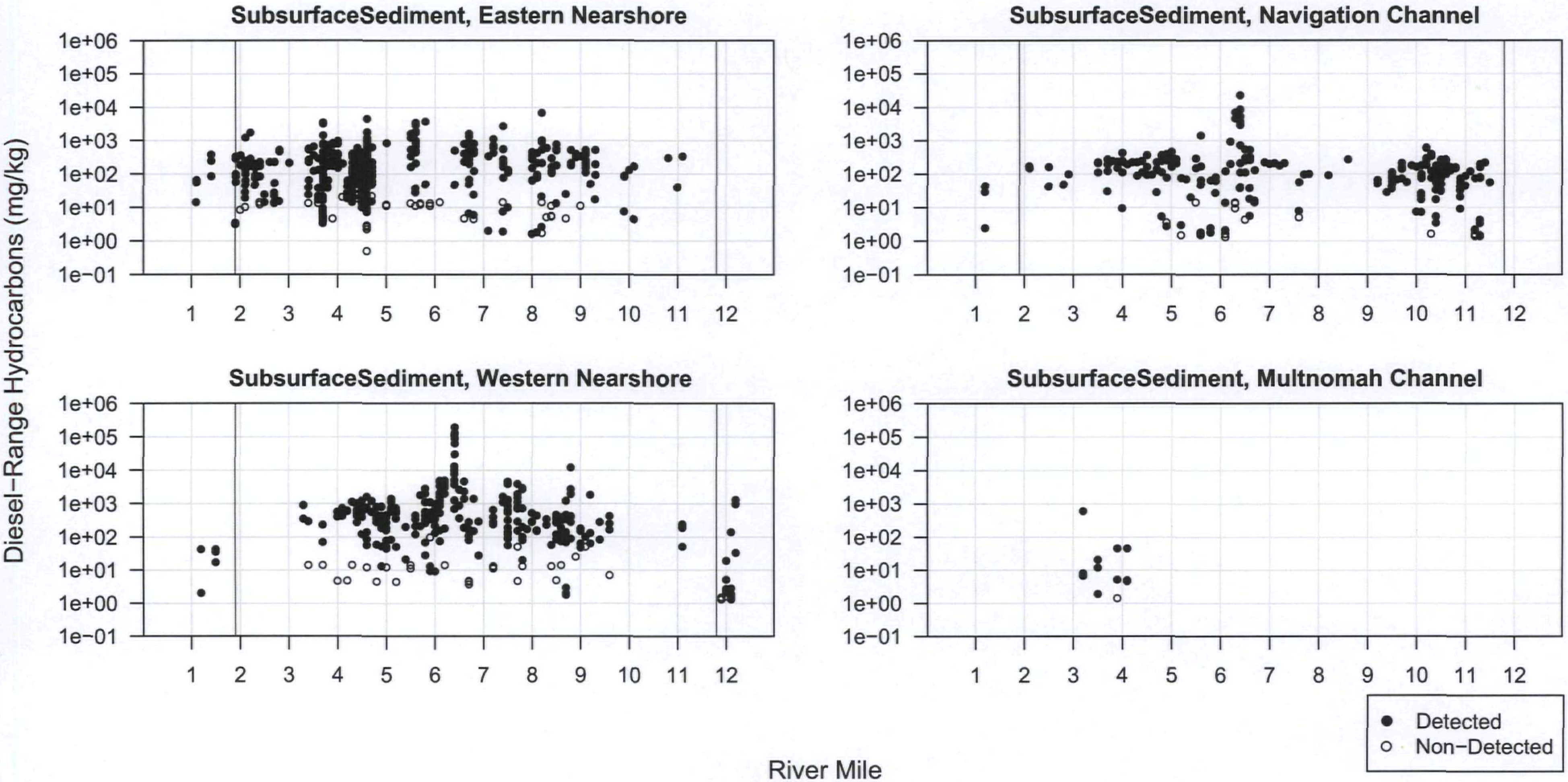

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Figure D1.3-30
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Diesel-Range Hydrocarbon Concentrations in Subsurface Sediment, RM 0.8-12.2

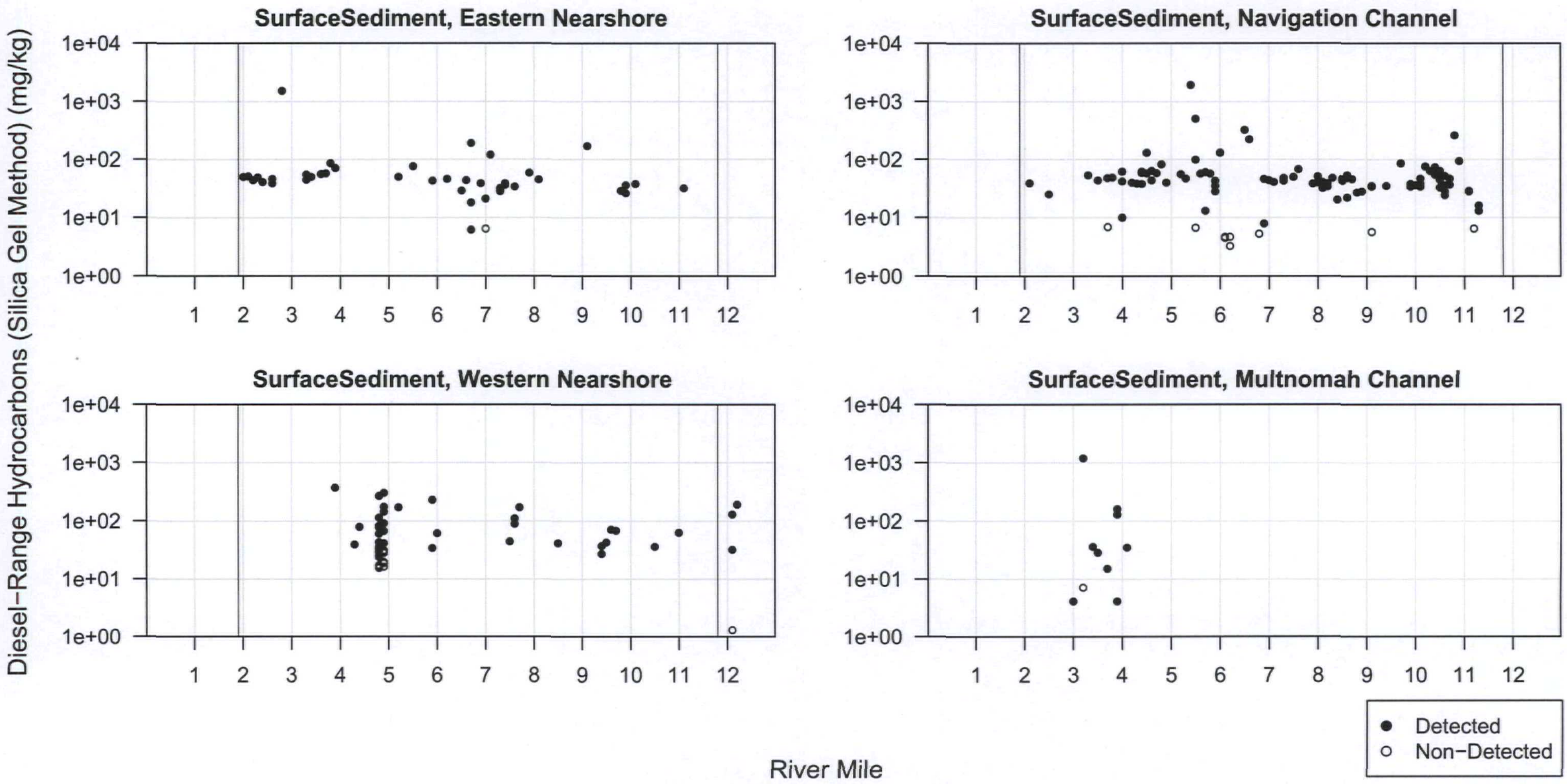

Figure D1.3−31
Portland Harbor RI/FS
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Scatter Plot of Diesel−Range Hydrocarbon (Silica Gel Method)
Concentrations in Surface Sediment, RM 0.8−12.2

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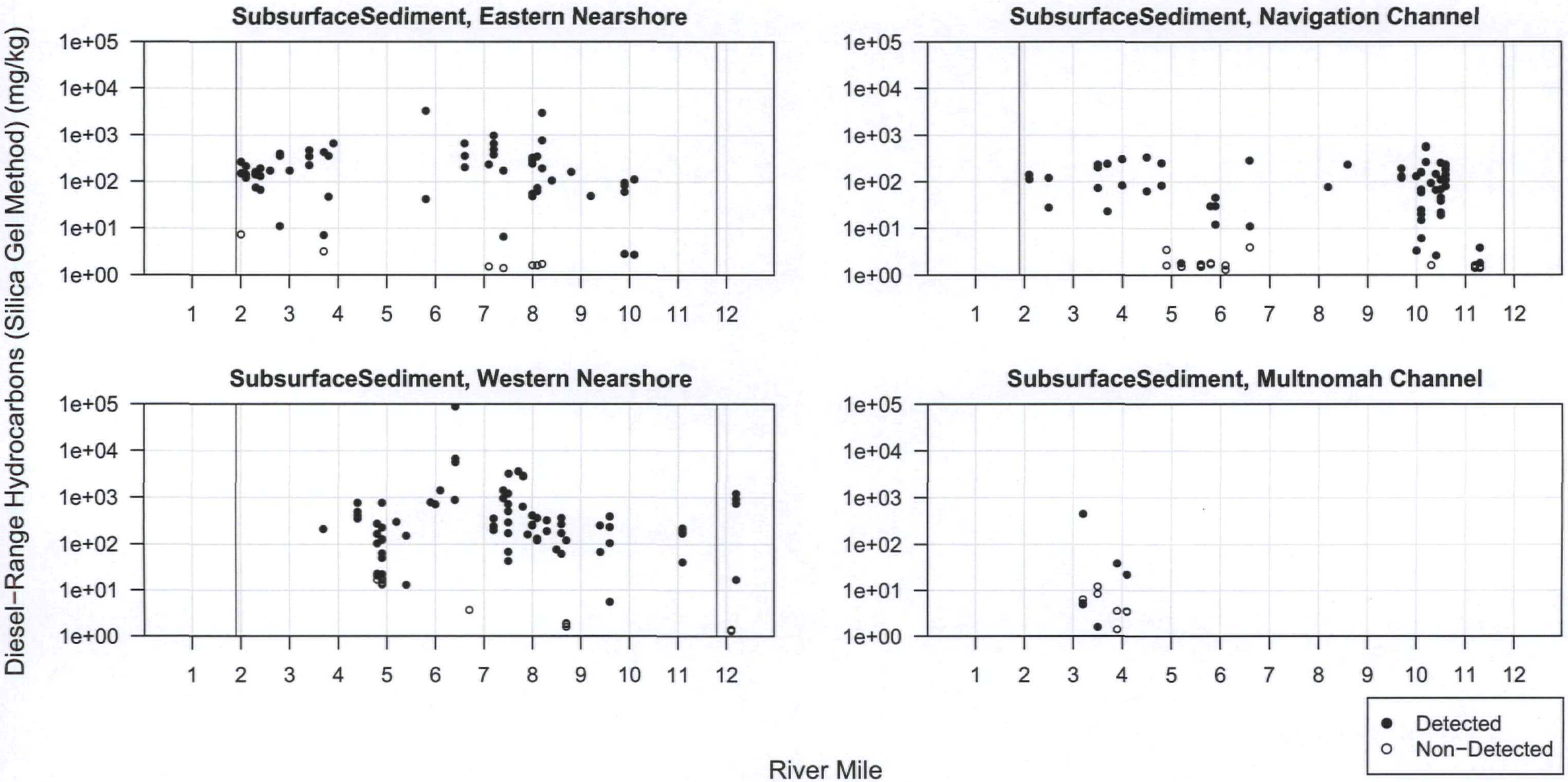

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Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Diesel-Range Hydrocarbon (Silica Gel Method) Concentrations in Subsurface Sediment, RM 0.8-12.2

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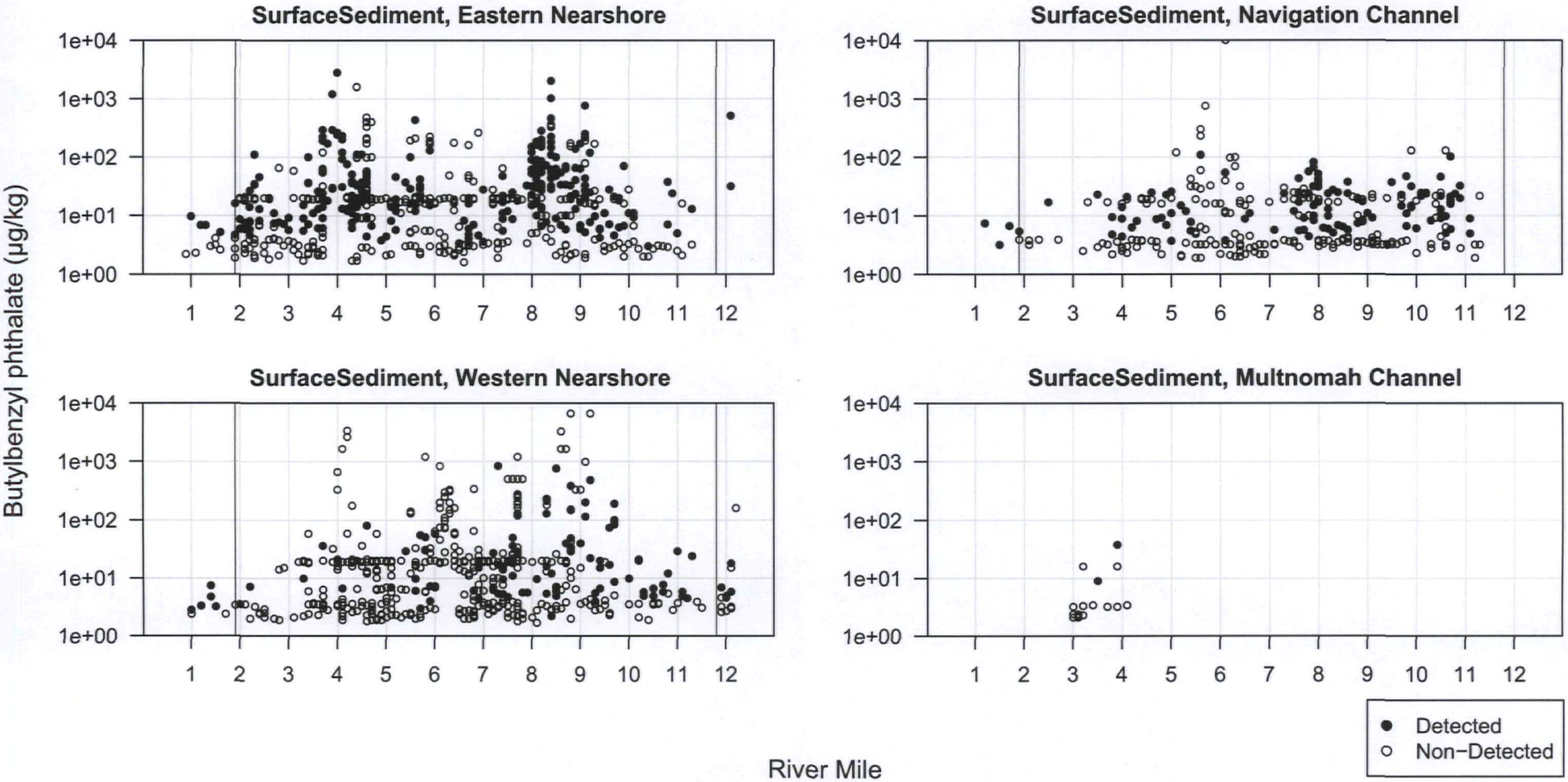

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Figure D1.3−33
Portland Harbor RI/FS
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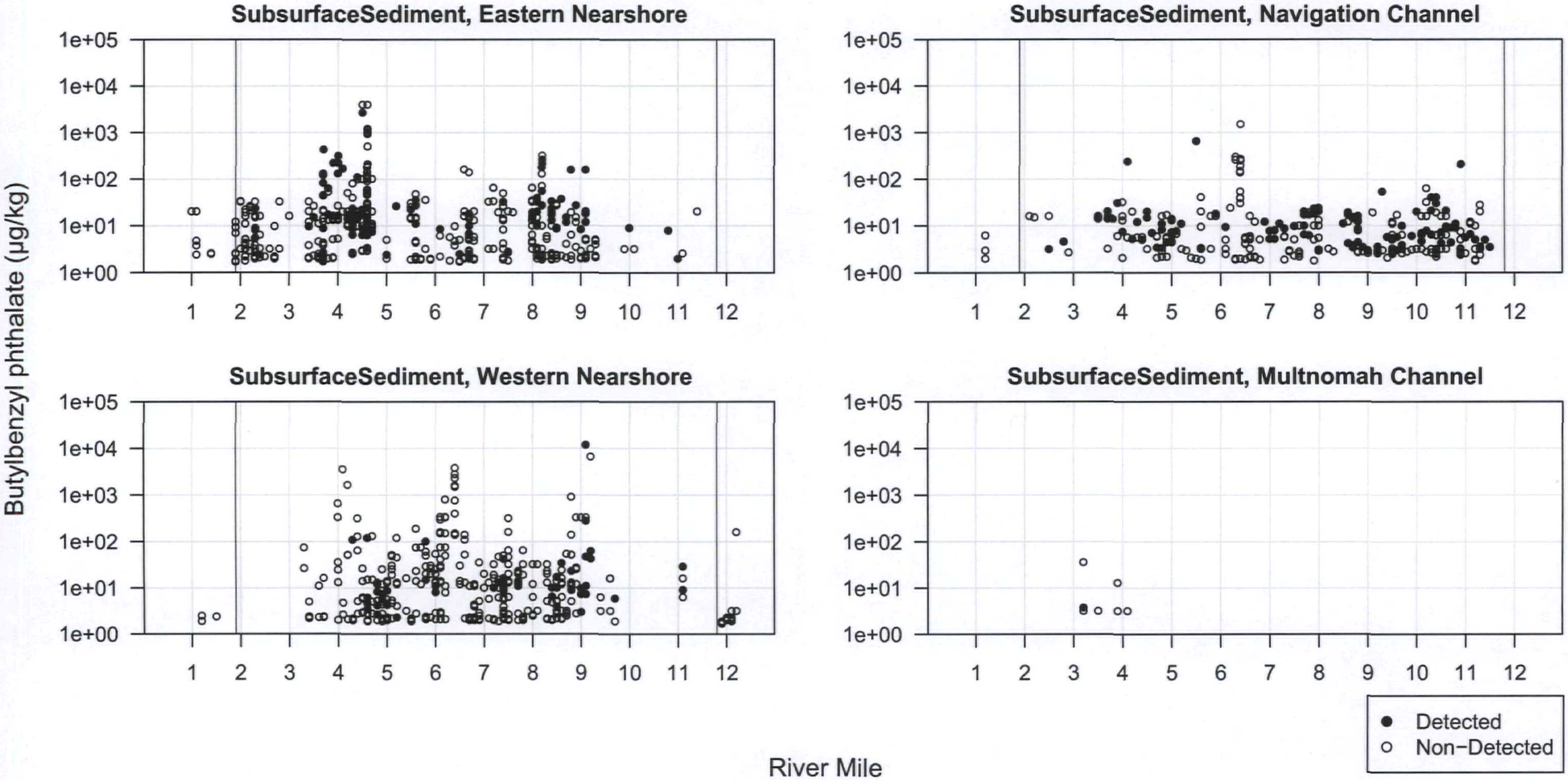
Scatter Plot of Butylbenzyl phthalate
Concentrations in Surface Sediment, RM 0.8−12.2



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Draft Remedial Investigation Report
Scatter Plot of Butylbenzyl phthalate
Concentrations in Subsurface Sediment, RM 0.8-12.2

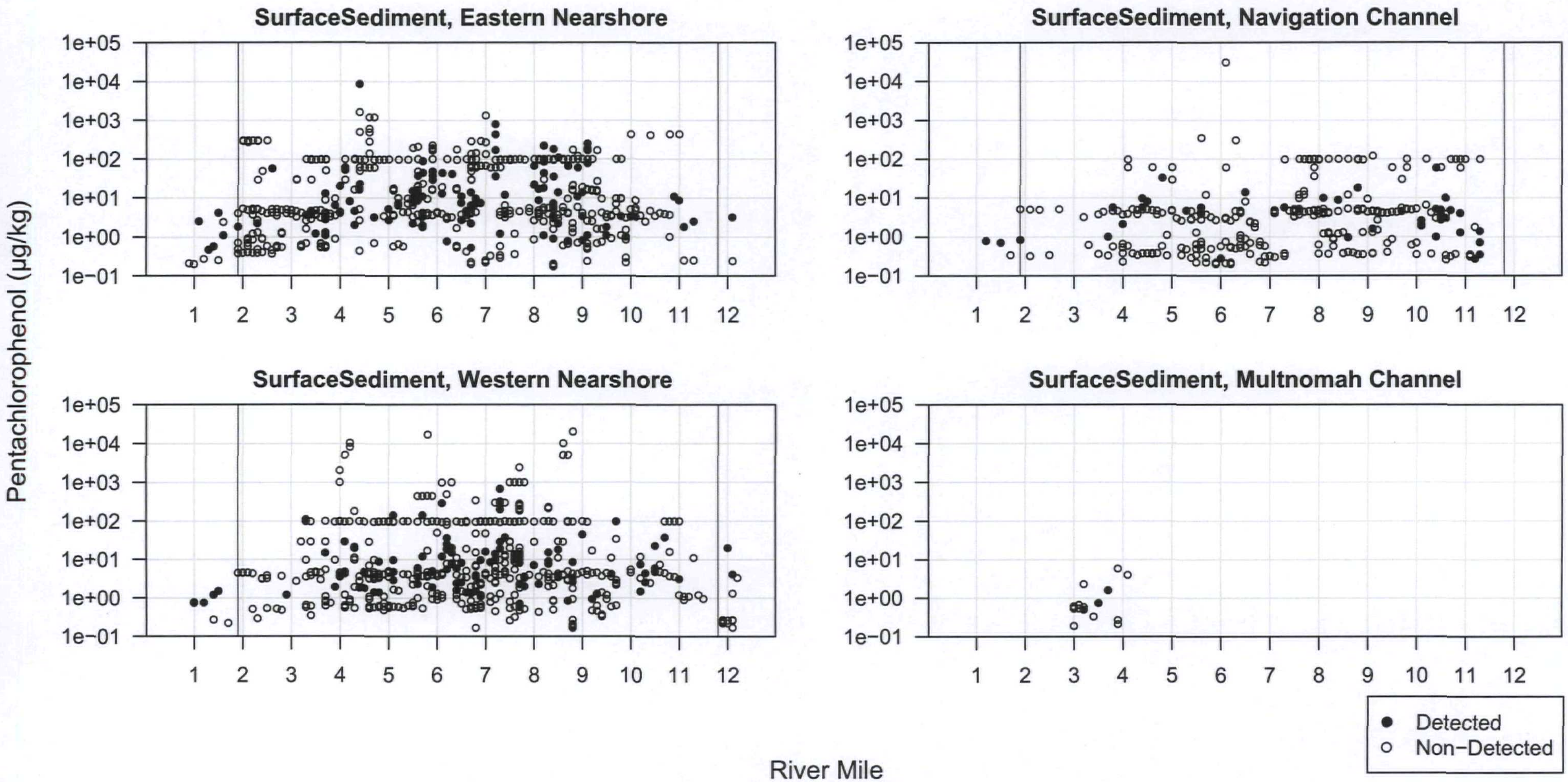

Figure D1.3-35
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Pentachlorophenol
Concentrations in Surface Sediment, RM 0.8-12.2

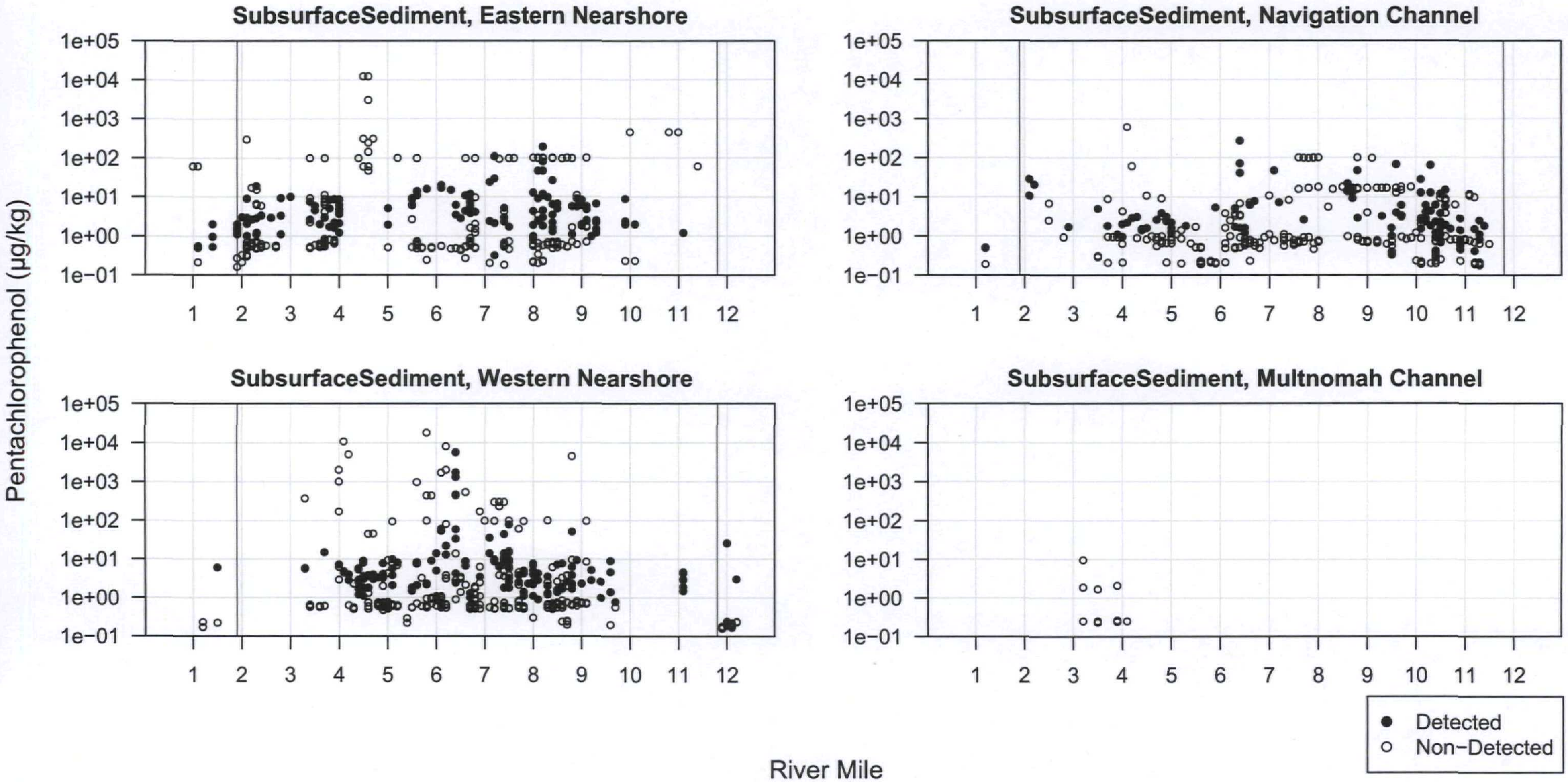

Figure D1.3-36
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Pentachlorophenol
Concentrations in Subsurface Sediment, RM 0.8-12.2

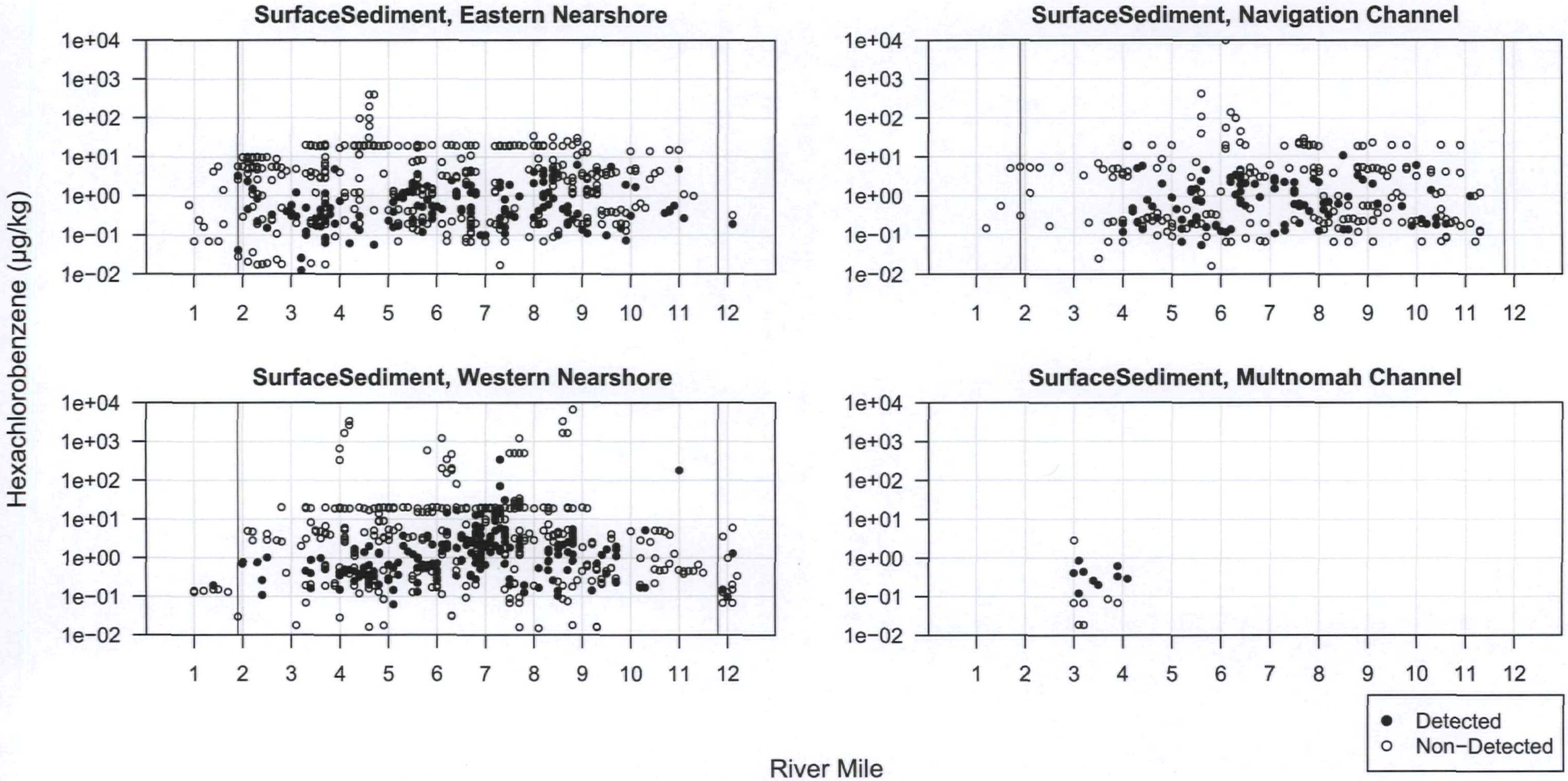

Figure D1.3-37
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Hexachlorobenzene
Concentrations in Surface Sediment, RM 0.8–12.2

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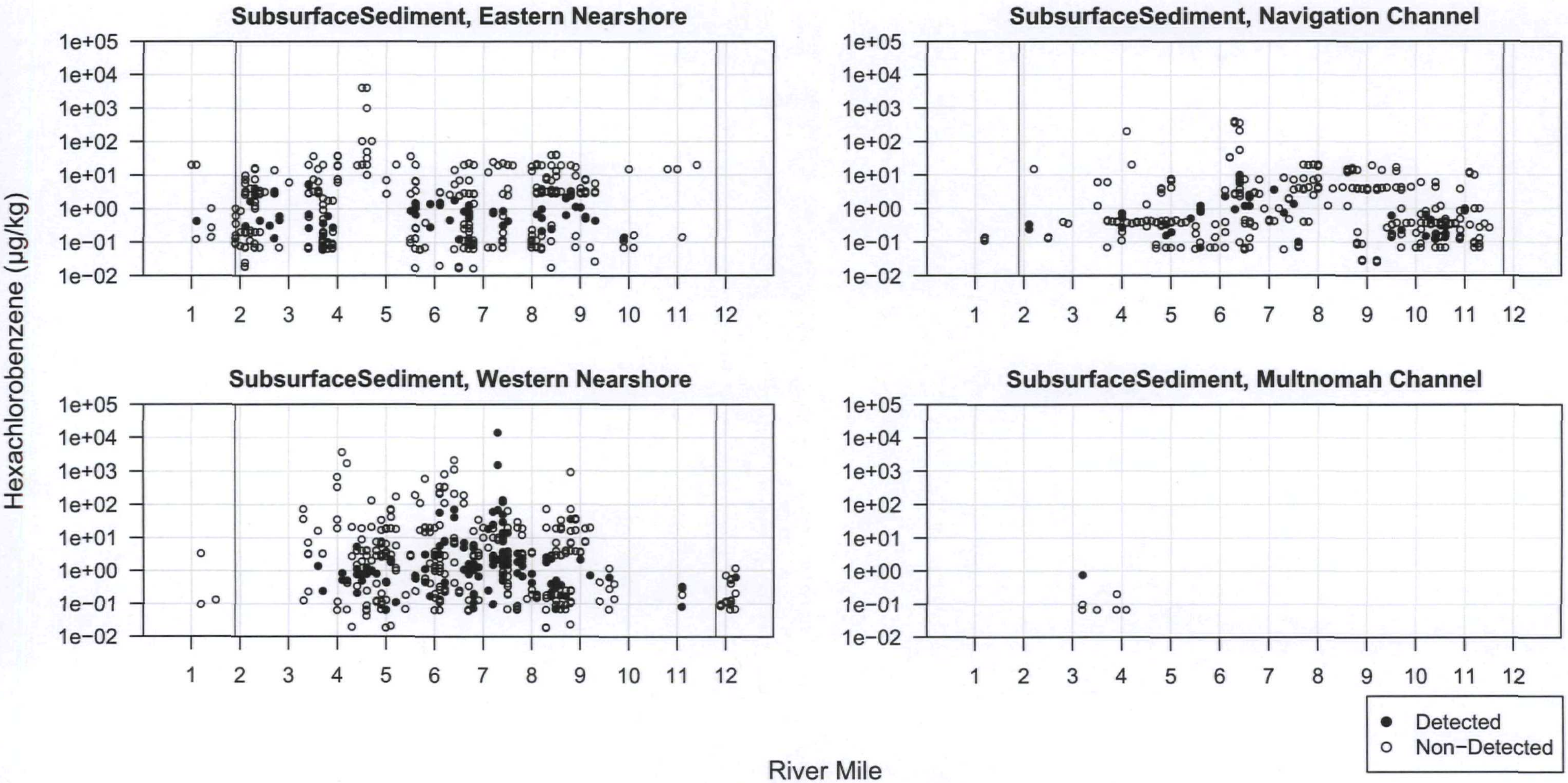

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Figure D1.3−38
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Hexachlorobenzene
Concentrations in Subsurface Sediment, RM 0.8−12.2

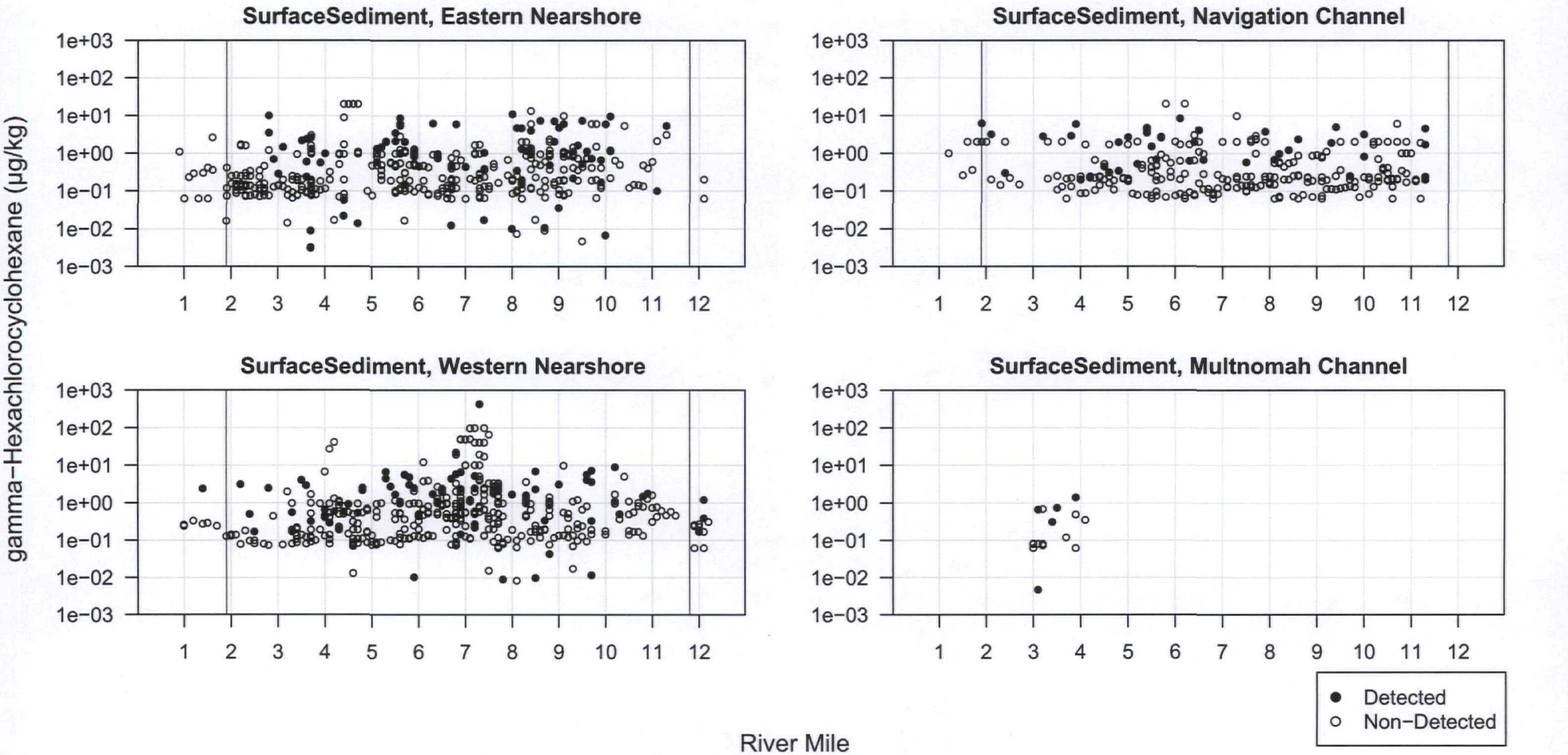

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Figure D1.3−39
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of gamma−Hexachlorocyclohexane Concentrations in Surface Sediment, RM 0.8−12.2

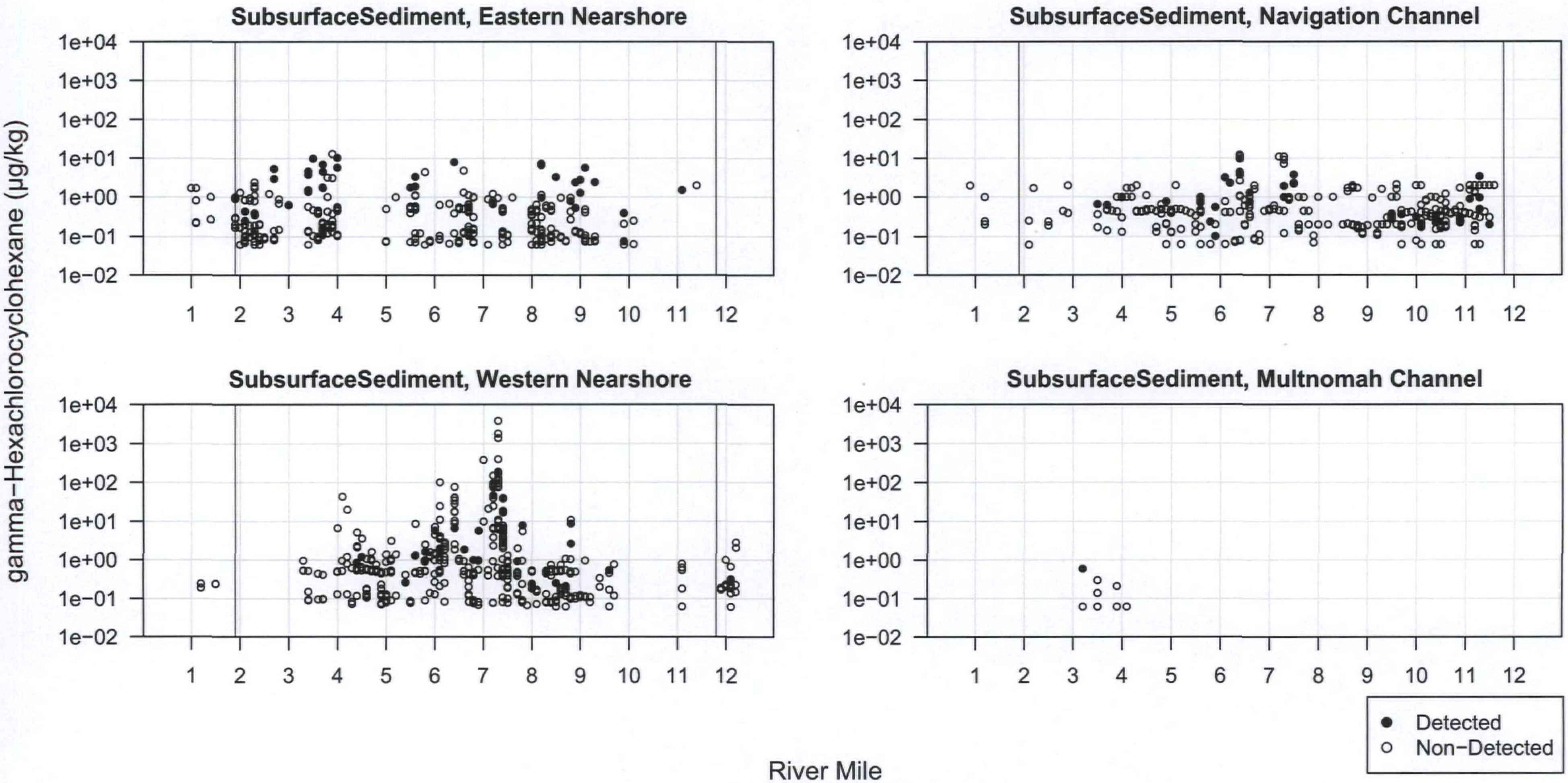

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Figure D1.3−40
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of gamma−Hexachlorocyclohexane Concentrations in Subsurface Sediment, RM 0.8−12.2

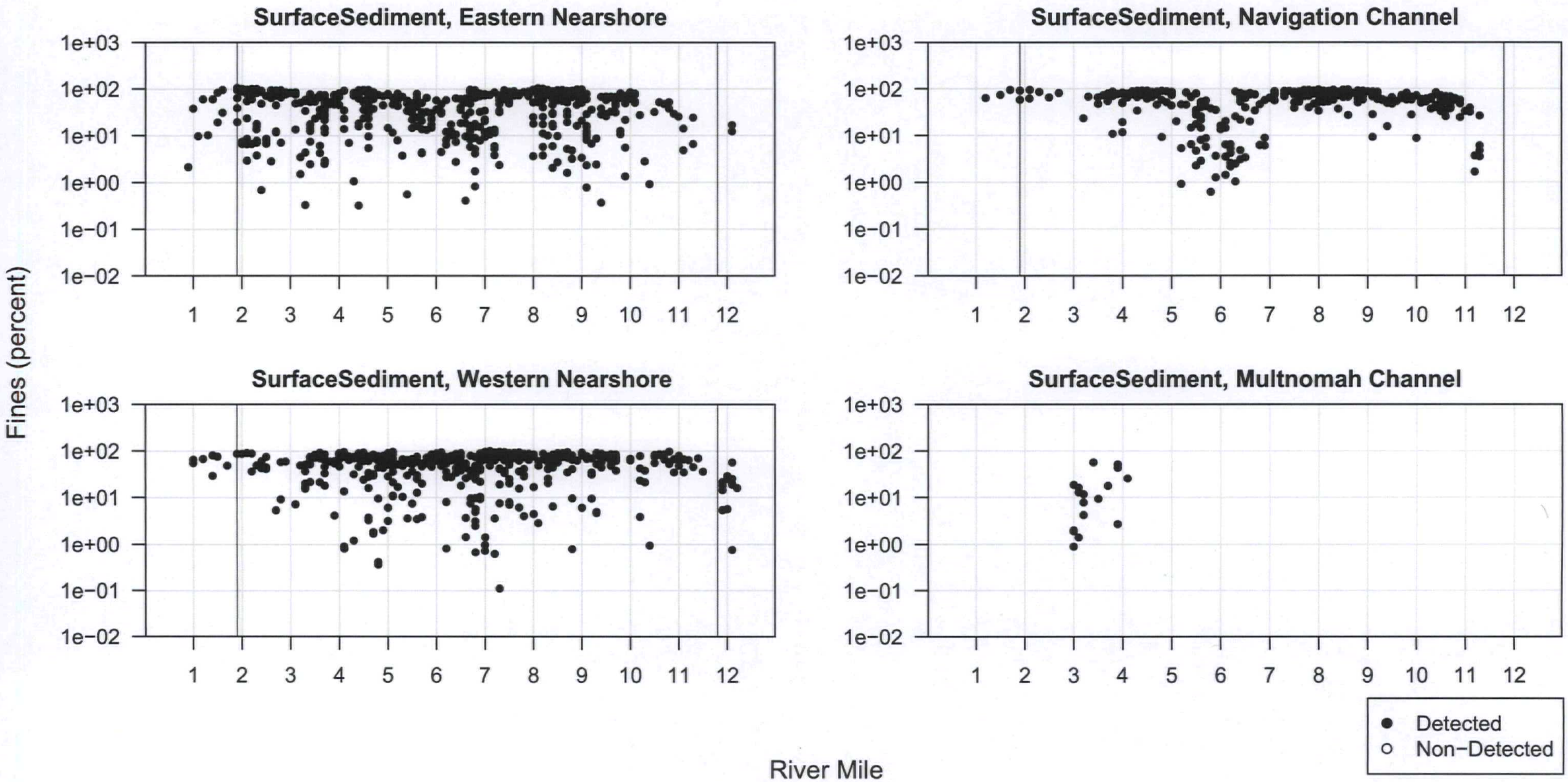

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Figure D1.3−41
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Fines
Concentrations in Surface Sediment, RM 0.8−12.2

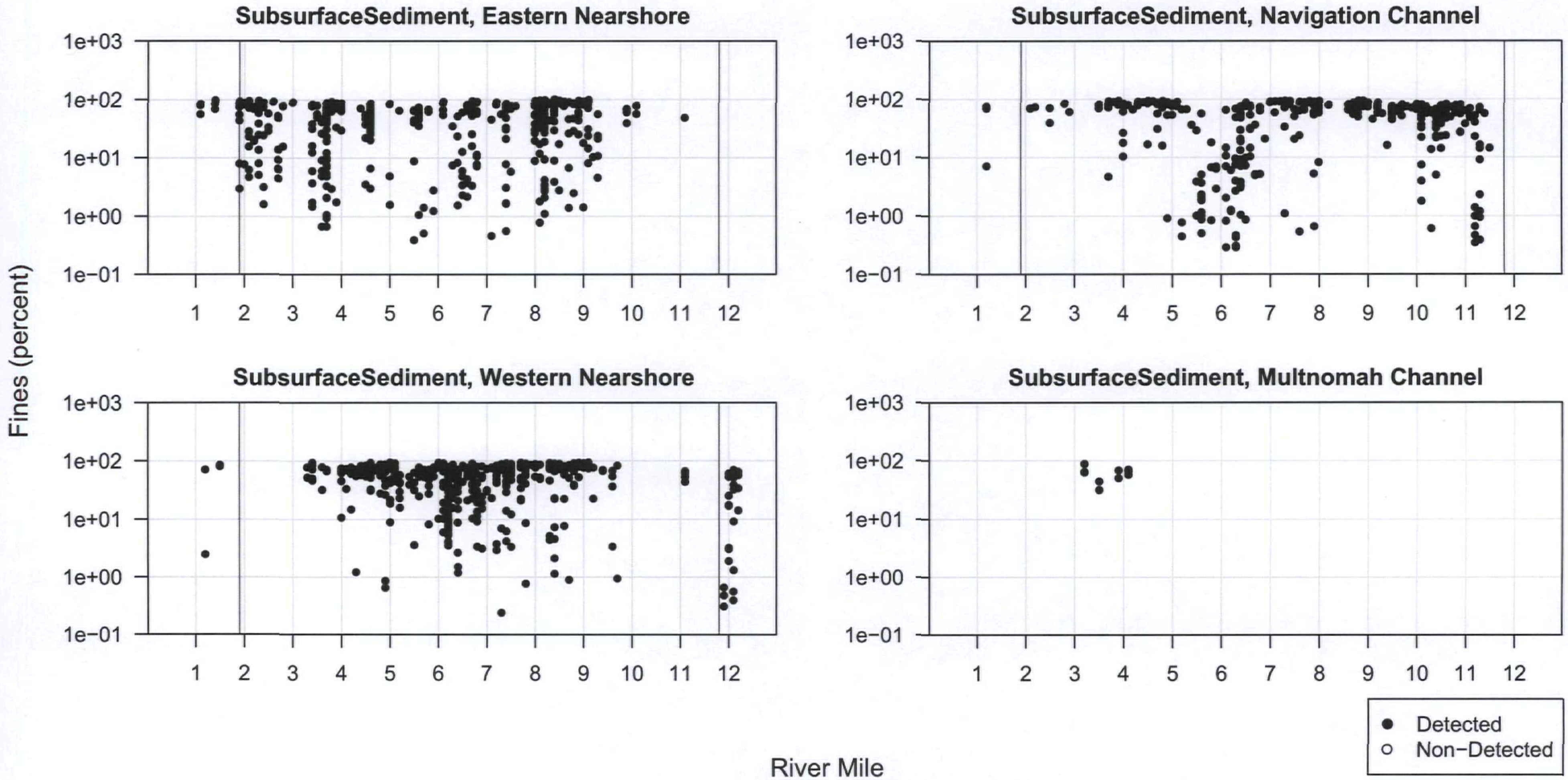

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Figure D1.3-42
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Fines
Concentrations in Subsurface Sediment, RM 0.8-12.2

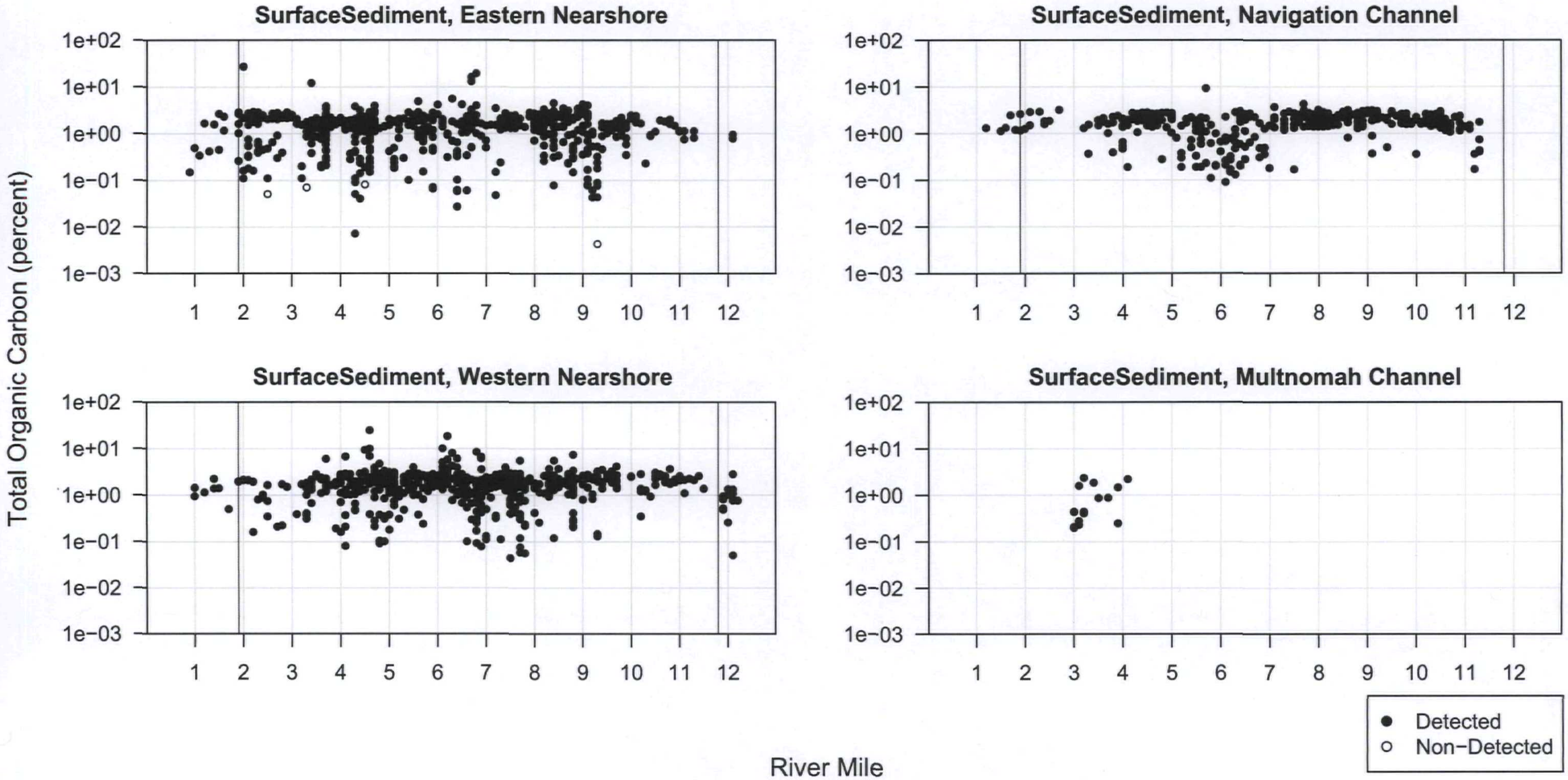

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Figure D1.3-43
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total Organic Carbon Concentrations in Surface Sediment, RM 0.8-12.2

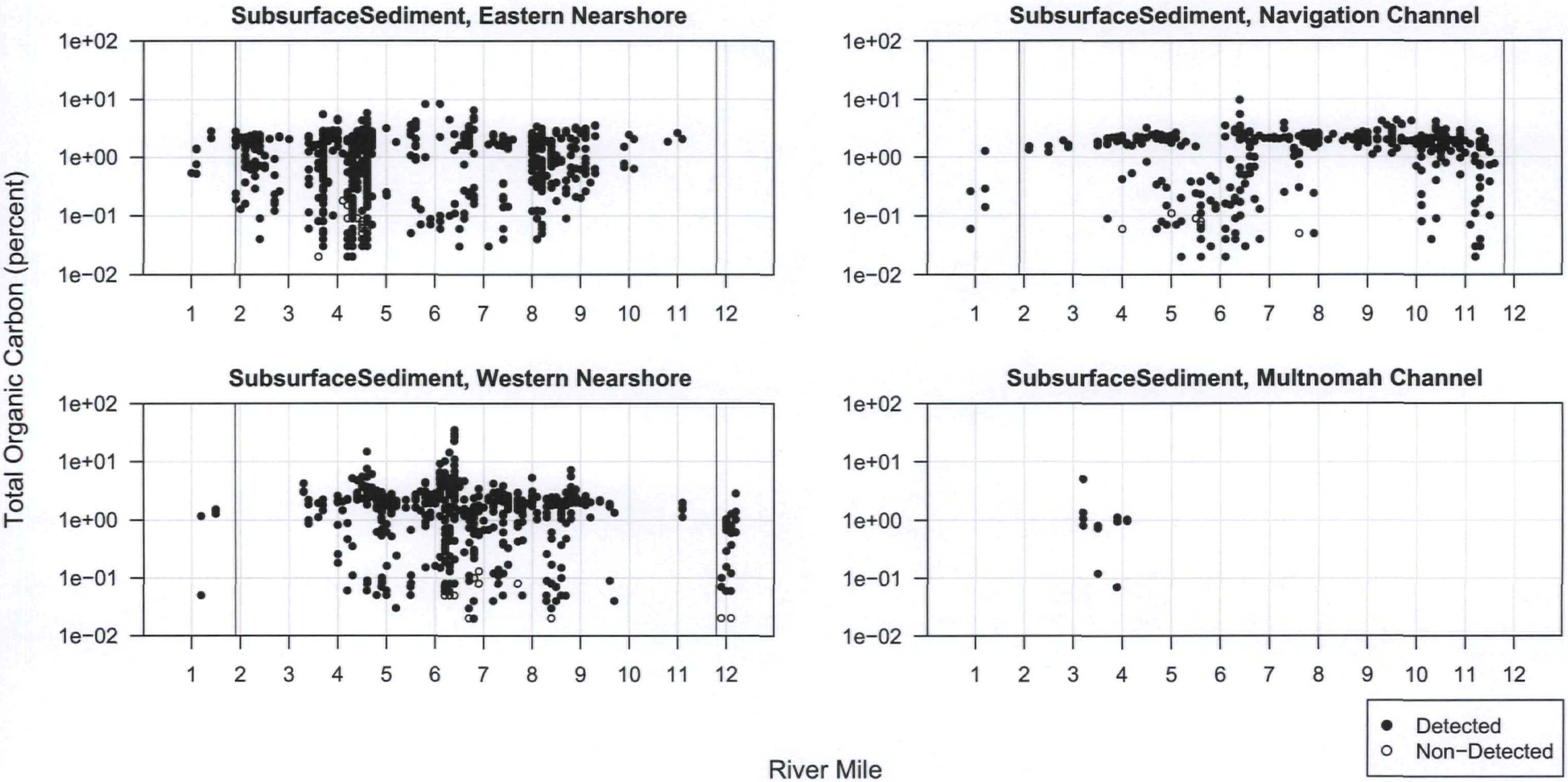

Figure D1.3-44
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total Organic Carbon
Concentrations in Subsurface Sediment, RM 0.8-12.2

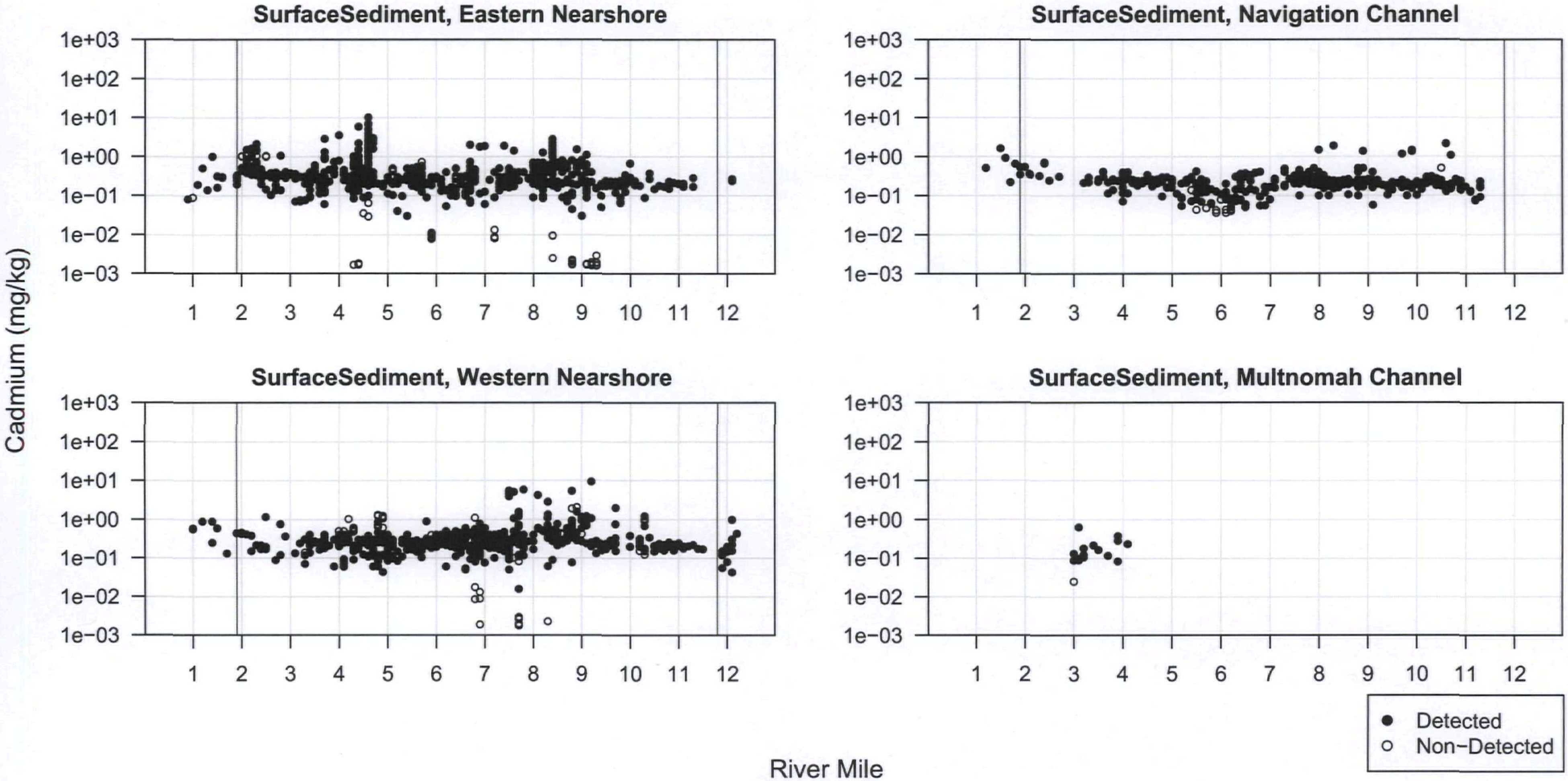

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Figure D1.3-45
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Cadmium
Concentrations in Surface Sediment, RM 0.8-12.2

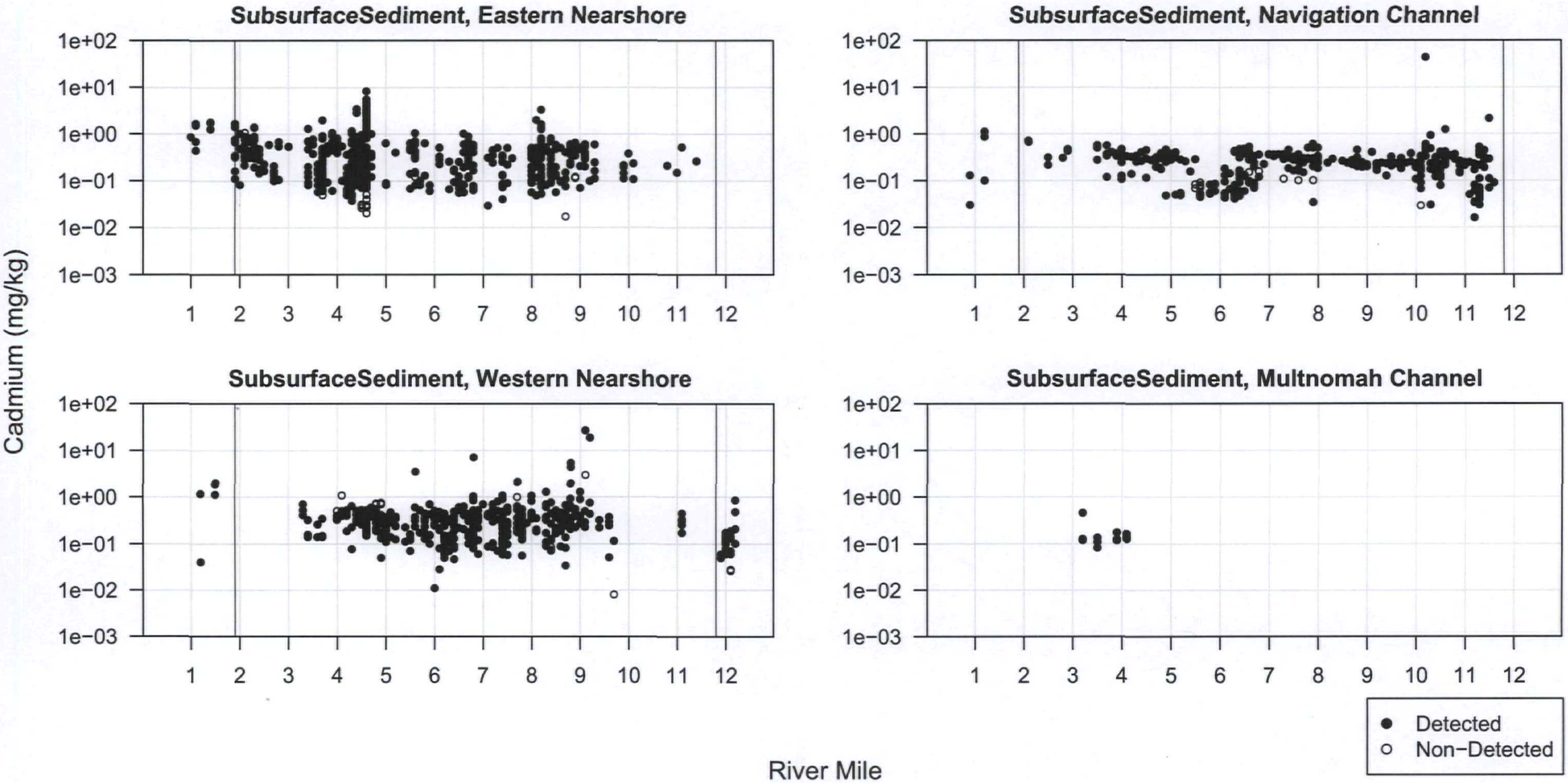

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Figure D1.3−46
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Cadmium
Concentrations in Subsurface Sediment, RM 0.8−12.2

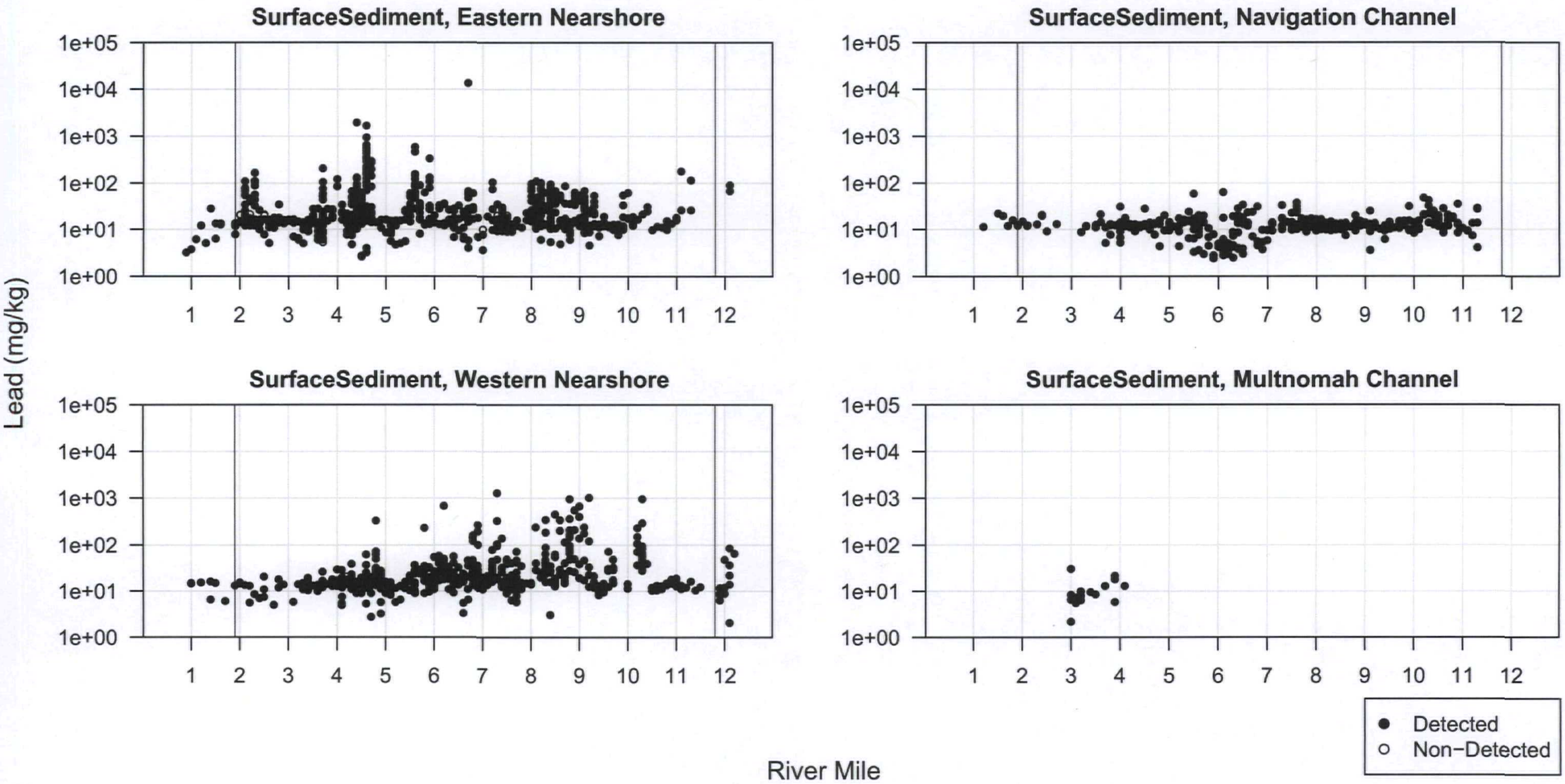

Figure D1.3−47
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Lead
Concentrations in Surface Sediment, RM 0.8−12.2

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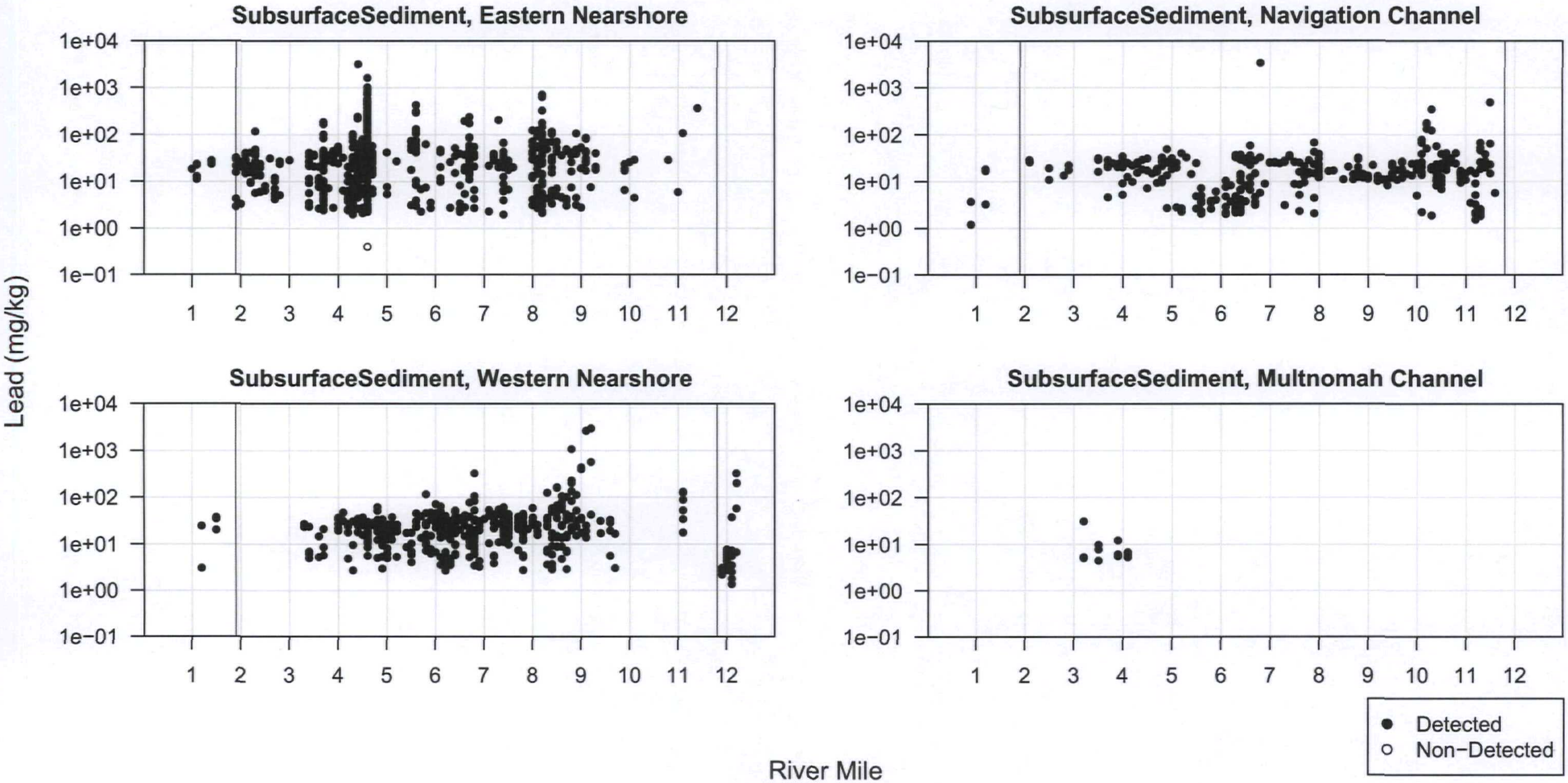

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Figure D1.3−48
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Lead
Concentrations in Subsurface Sediment, RM 0.8−12.2

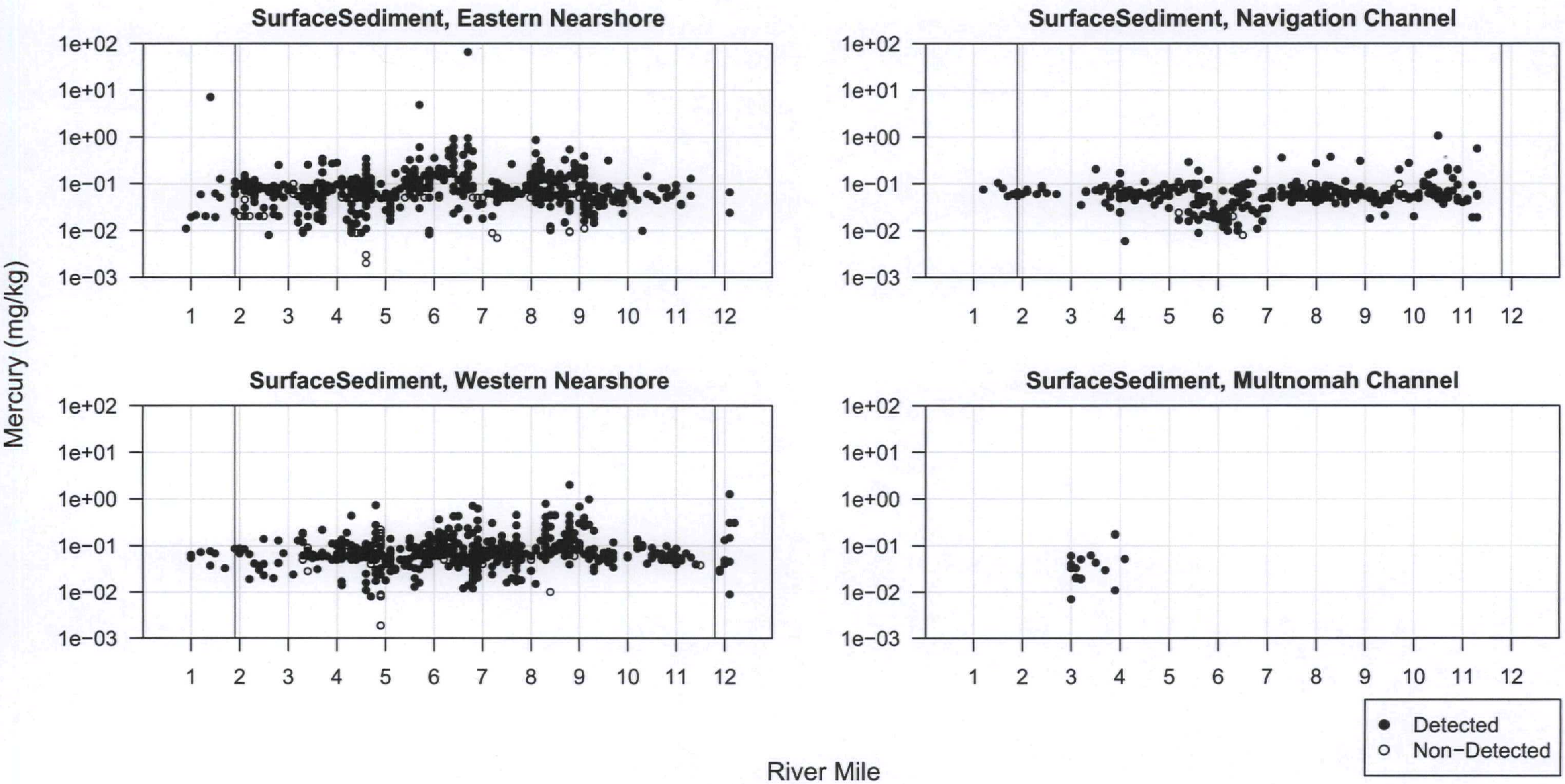

Figure D1.3−49
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Mercury
Concentrations in Surface Sediment, RM 0.8−12.2

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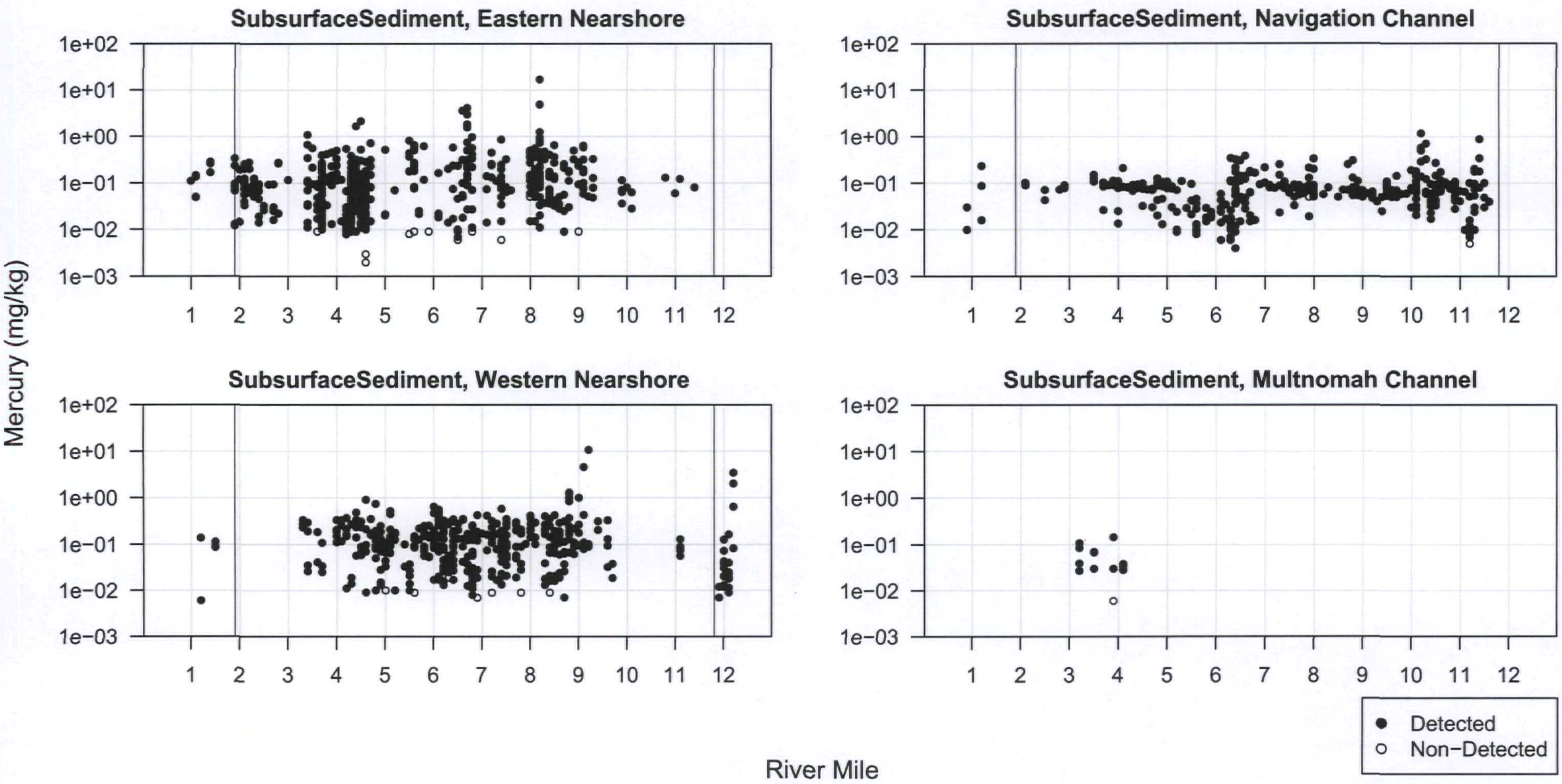

Figure D1.3−50
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Mercury
Concentrations in Subsurface Sediment, RM 0.8−12.2

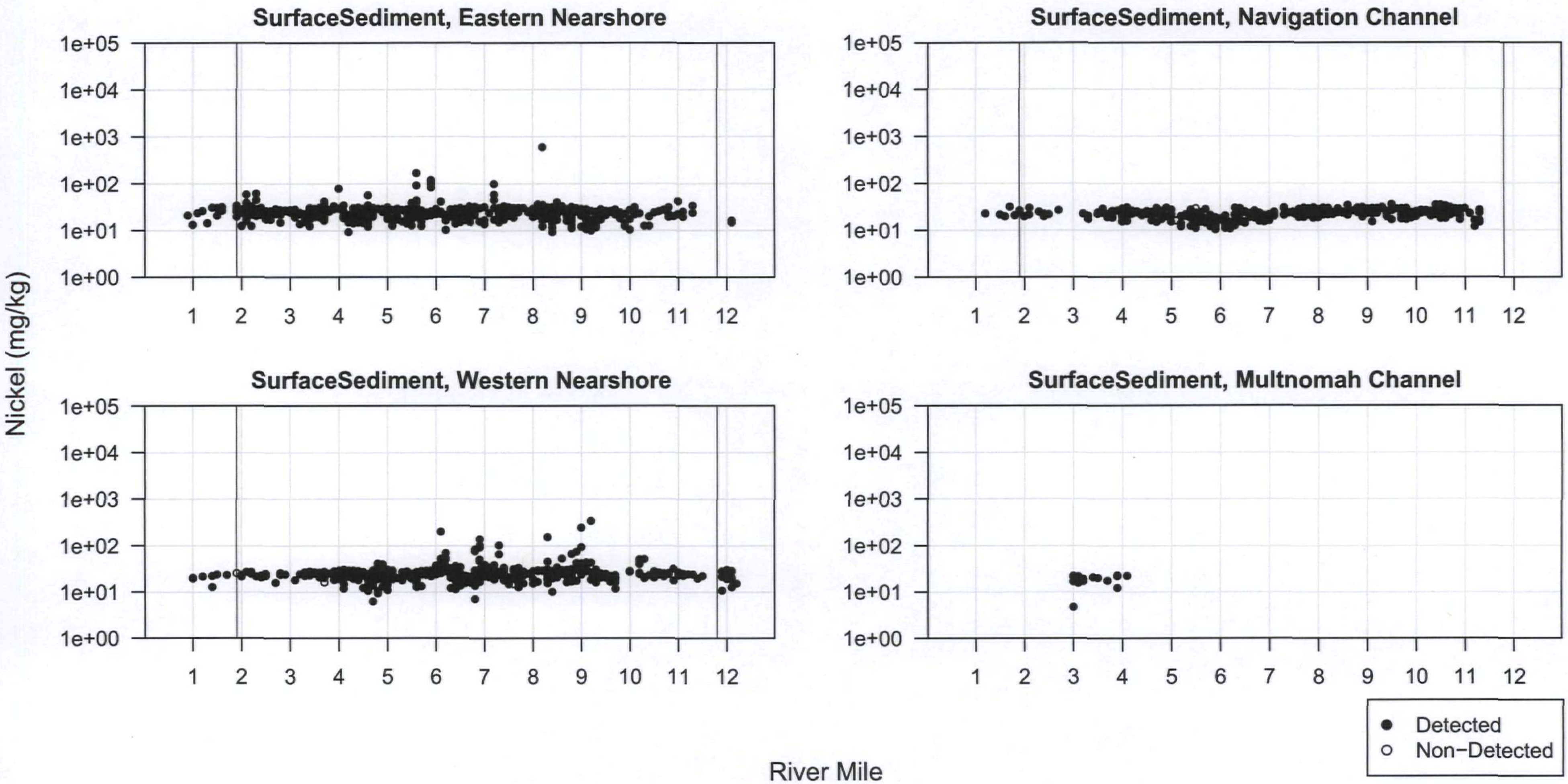

Figure D1.3-51
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Nickel
Concentrations in Surface Sediment, RM 0.8-12.2

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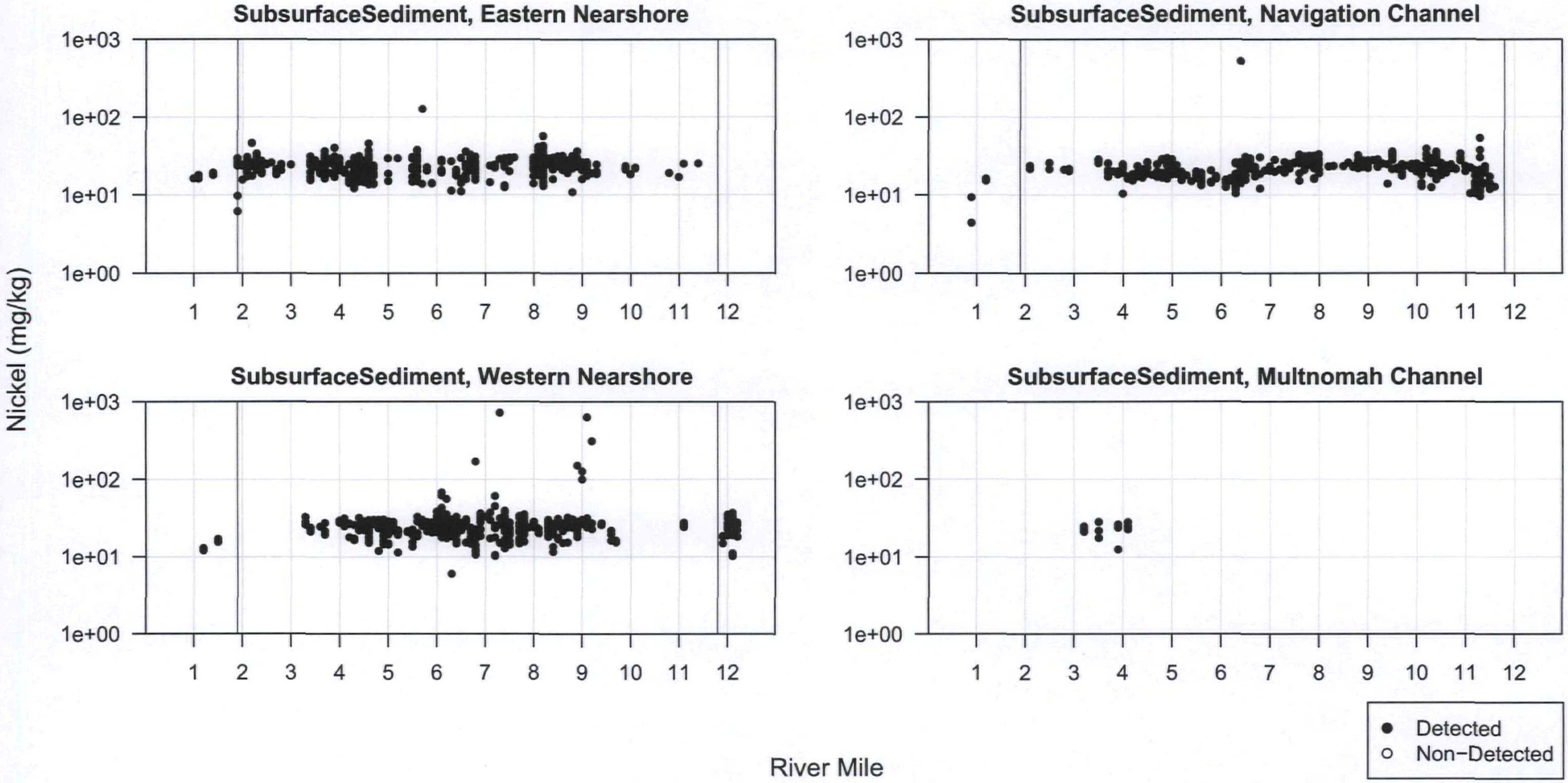

Figure D1.3−52
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Nickel
Concentrations in Subsurface Sediment, RM 0.8−12.2

Appendix D1.4

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REMEDIAL INVESTIGATION REPORT

APPENDIX D1.4
COMPARISON AND USE OF PCB AROCLOR AND CONGENER DATA

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October 27, 2009

APPENDIX D1.4 COMPARISON AND USE OF PCB AROCLOR AND CONGENER DATA

D1.4.1 Introduction

Depending on the objectives of the specific investigation, two types of PCB analyses were used for Portland Harbor RI samples: 1) identification and quantification of PCBs as Aroclors using gas chromatography with electron capture detection (most commonly by EPA method 8082), and 2) direct analysis of PCB congeners. PCB congener analysis is generally performed using high-resolution gas chromatography with high-resolution mass spectrometry (EPA method 1668A); however, some data using method 8082 for congeners are included in the Portland Harbor SCRA Database (Tetra Tech 2006). In order to provide a clear representation of the patterns and trends of PCBs in the Study Area, PCB totals based on both congeners and Aroclors are displayed together on maps and graphs in Section 5 for sediments and biota. As described below, the PCB congener analysis is preferred when available and should be given greater weight in any analysis. However, both sets of data can be useful for generally assessing the spatial distribution of PCBs and combining both types of data allows presentation of the most complete and representative data set.

The numbers of available samples from the Study Area and adjacent and upstream areas that were analyzed for Aroclors and PCB congeners are as follows:

Matrix	Number of Samples Analyzed for Aroclors	Number of Samples Analyzed for PCB Congeners	Number of Samples Analyzed for Both Aroclors and PCB Congeners
Surface Sediment	1,514	299	290
Subsurface Sediment	1,539	151	149
Biota	170	369	89
Sediment Trap Samples	48	52	48

This appendix provides a description of the analytical methods used for Aroclors and PCB congeners with supporting information to provide context for these methods, followed by a comparison and evaluation of the total PCB data obtained by the two methods.

D1.4.2 PCB Analysis Methods

In North America the primary source of PCBs to the environment was the industrial use of Aroclors (Sather et al. 2001). Aroclor® was the trade name for various PCB mixtures produced by the Monsanto Corporation. The nine most commonly analyzed Aroclors are Aroclors 1221, 1232, 1016, 1242, 1248, 1254, 1260, 1262, and 1268. The last two numbers in the Aroclor name indicate the percent of chlorine, by weight, in the technical mixture. Aroclor 1016 is an exception to this rule, with 41 percent chlorine by weight. The PCB congener (and homolog group) distribution of each Aroclor is unique (Newman et al. 1998), as shown in Figure 5.1-34.

Historically, most PCB analyses have been based on Aroclors, reflecting the primary source of the PCBs. Aroclor identification is generally performed by comparing the chromatogram of a sample to chromatograms of Aroclor standards. Each Aroclor has a PCB congener composition that yields a characteristic pattern of peaks. If the PCB pattern observed in the sample matches an Aroclor standard, the Aroclor is identified as present in the sample and quantified.

Several factors complicate Aroclor analyses, including "weathering," differences between Aroclor formulations and production lots, and the presence of multiple Aroclors and chemical interferents. "Weathering" can modify Aroclor patterns in samples, including processes such as partitioning, photolysis, and biodegradation. In general, the more chlorinated the PCB congener, the more persistent it is in the environment. However, various "weathering" processes may remove less chlorinated or more highly chlorinated congeners (Erickson 1997); conversely transport processes may enrich some congeners. Additionally, other "weathering" processes may selectively remove congeners from an Aroclor pattern without production of new congeners (Frame et al. 1996). Photolytic and anaerobic microbial dechlorination can lead to the presence of congeners not originally present in Aroclors. The congener composition of PCBs found in environmental samples frequently differs greatly from the source Aroclors (Sather et al. 2003), and these changes can affect the ability of the laboratory to accurately identify or quantify the PCBs.

Analyses of the PCB congener distributions in Aroclors have also shown that different production lots of an Aroclor can have different congener compositions (Frame et al. 1996). The differences in homolog distributions between the lots were relatively minor; however, differences in PCB congener distributions were more significant. These differences can introduce error to the quantification of Aroclors to the extent that the standards and released Aroclors are dissimilar in PCB composition.

It is also common in environmental samples to encounter interferences from non-PCB sources or multiple Aroclors. The presence of such background interferences or effects of "weathering," or both, can make it difficult to differentiate between Aroclors with similar chlorine content, such as Aroclors 1016 and 1242, 1242 and 1248, or 1260 and 1262. The co-occurrence of Aroclors in a sample can also make identification of Aroclor patterns difficult (EPA 2007).

In addition, the presence of multiple Aroclors, weathered PCBs, and interferences may cause the laboratory to elevate detection limits for affected Aroclors. This was the case with a number of samples collected for the Portland Harbor RI/FS. For the RI data set, non-detected Aroclors are treated as zero in the summation to calculate total PCB Aroclors (if no Aroclors are detected, then the highest detection limit is used for the total PCB detection limit). If PCBs are present at a concentration below the elevated Aroclor detection limit but above the regular detection limit, the total Aroclor value may underestimate total PCBs.

Quantification of PCBs as Aroclors is based on the assumption that the PCB congeners in the sample are present in the same ratio as in the Aroclor that is used as a standard. As a result, when a sample has undergone substantial modification due to "weathering," or when two or more source Aroclors are present that have congeners in common, the quantification of the PCBs as Aroclors may not fully reflect the concentration of PCB congeners present in the sample. The bias may be high or low, depending on whether the peaks used to quantify the Aroclors represent congeners that are depleted or enriched relative to their concentration in the original source Aroclor. The magnitude and direction of the bias are also affected by the extent to which the ratio between peaks used to quantify the Aroclors and the remaining peaks has been altered. This is a source of error that is inherent in the method and can result in differences between total PCBs analyzed as Aroclors or by direct measurement of congeners. Nevertheless, Aroclor analyses are based on established methodology and are widely used. Total Aroclor concentrations are considered to be sufficiently reliable for RI/FS purposes.

The analysis of PCB congeners is more expensive and time-consuming than Aroclor analysis, but it is less affected by the factors described above. Each congener of interest is identified and quantified separately. When all 209 congeners are analyzed, any congeners that were not initially present in the Aroclors, or originated from other sources, are also accounted for. PCB congener analysis is usually performed using mass spectrometry, which is better able to differentiate PCBs from non-PCB interferences and is therefore less influenced by the presence of other chemicals. Additionally, the method employed for the analysis of PCB congeners is more sensitive than the Aroclor method and will detect congeners at lower levels than the Aroclor method. Examples of this sensitivity are seen in the RI data set, which includes 90 samples (65 sediments, 18 sediment trap samples, and 7 biota) with detections for PCB congeners when Aroclors were undetected.

The total PCB congener and total Aroclor data for sediments and biota were combined into a single data set to facilitate characterization of PCBs in the Study Area. These total PCB data were used to create Maps 5.1-1 and 5.1-2a–m. Due to the laboratory method and analytical considerations discussed above (and with the exception noted below), the total PCB data set includes the result for total PCB congeners for each sample when available, and the result for total Aroclors when no total PCB congener data are available. However, total Aroclor data were selected to represent total PCBs for Round 2A beach sediment samples even though congener analyses were also conducted, because the beach samples were only analyzed for coplanar PCB congeners, which constitute a small fraction of Aroclor-related congeners. Congener analyses for the remaining LWG sediment samples included all 209 congeners. Total PCB data for the Study Area are available for 1,184 surface and 1,325 subsurface samples. Most of the PCB data are based on Aroclor analyses (Tables 5.1-1 and 5.1-2).

D1.4.3 Comparison of Total Aroclor and Total PCB Congener Concentrations

The total Aroclor and total PCB congener results were evaluated to determine the comparability of data obtained by the two PCB methods. Scatter plots displaying PCB concentrations by river mile within the Study Area are provided in Figures D1.4-1a–b. In general, the high total Aroclor concentrations correspond well with the high total congener concentrations spatially; the two data sets are consistent in their representation of the distribution of total PCBs and identification of areas of high PCB concentrations.

The concentrations obtained using the two PCB methods were compared by regressing the total congener concentration on the total Aroclor concentration for samples that were analyzed by both methods, as shown in Figure D1.4-2. Data were log-transformed to satisfy the assumptions of normality for linear regression analysis. For sediments, data were available from RM 1.4 to 18.8 and Multnomah Channel, and for tissues, data were available from RM 2.4 to above the falls. Sediment trap data were available from RM 1.8 to 15. The numbers of samples used in these plots are fewer than the sample counts tabulated above, as samples with non-detects are excluded. Biota (coefficient of determination [r^2] = 0.87) showed the best correlation, with subsurface sediments showing the poorest ($r^2 = 0.48$). For all data assessed together, r^2 was 0.70. The slopes of the regression formulae are less than 1 for all matrices except sediment traps, indicating that the total Aroclor data provide a higher total PCB estimate overall than total PCB congener data. This is not unexpected as "weathering" processes or the presence of multiple Aroclors or chemical interferences can lead to a high bias in total Aroclor results.

The regressions of PCB Aroclor and congener concentrations were not significantly different for surface and subsurface sediment data ($P = 0.42$). These two data sets were analyzed together ($N = 360$) and their regression ($r^2 = 0.88$, $P < 0.01$) statistically compared to the 1:1 line (Figure D1.4-3). This analysis indicated that total Aroclor data tend to overpredict (using the log-log linear regression) total PCB congeners in concentrations below ~750 μg/kg (total PCB Aroclors) and may result in underprediction above this threshold.

For the surface sediment data, an in-depth Simulation-Extrapolation procedure was performed to assess the effect of measurement error of Aroclor concentrations on the regression-predicted values of total PCB congener concentrations. The methods and results of this analysis are presented in Attachment D1.4.1. In short, this analysis highlights increasing uncertainty in the predictive power of a linear model between total Aroclor and congeners in surface sediment with increasing total Aroclor concentrations.

D1.4.4 QC Sample Variability

Several types of quality control (QC) samples were collected to assess field and laboratory precision, including field duplicates (i.e., post-homogenization split samples) for Aroclors and PCB congeners, laboratory duplicates (separate analyses of the same sample) for PCB congener analyses, and matrix spikes and matrix spike duplicates (MS/MSDs) for Aroclor analyses. The variability of these QC samples provides a measure of the extent to which the variability observed in the Aroclor and congener data may be attributed to field and laboratory procedures. Scatter plots of field and laboratory duplicate concentrations are provided in Figures D1.4-4 and D1.4-5a–b. These figures include samples collected by the LWG for which Aroclors and PCB congeners were both detected. A summary of the relative percent difference values for environmental and QC samples is provided in Table D1.4-1.

Among the different levels of replication illustrated in Figures D1.4-4 through D1.4-5a–b and summarized in Table D1.4-1, laboratory duplicate, MS/MSD, and field duplicate results all showed better correlation overall than total PCBs analyzed as Aroclors and congeners in the same samples. One would expect the correlation to be highest between MS/MSDs and laboratory duplicates because the same sample jar and the same laboratory and method are used for these analyses. Field duplicates were collected in different jars, as were the samples for the two different PCB analyses for this investigation, but the same laboratory analyzed the field duplicates, often in the same processing batch. Samples for Aroclor and PCB congener analyses, however, were analyzed from different jars and by different laboratories using different extraction and cleanup procedures. This combination of conditions would be expected to yield greater variability between Aroclor and PCB congener results than MS/MSDs, laboratory duplicates, and field duplicates for each of the PCB analyses. Nonetheless, it can be seen in Table D1.4-1 that a sizable portion of the measured variability can be attributed to the environmental sample collection and analysis process.

While total Aroclor and total congener results generally track each other across the entire data set, there is a small subset of samples where the totals measured by the two methods diverge dramatically. Aroclors and PCB congeners were detected in a total of 535 samples, and the total Aroclor and total congener concentrations differed by more than a factor of 10 in 11 (or 2 percent) of these samples. These samples are listed in Table D1.4-2. For these 11 samples, the differences between the results by the two PCB methods are markedly greater than would be expected based on differences between the two PCB methodologies.

To investigate these differences, the laboratory data were examined for all samples with greater than ten-fold differences between reported total PCB Aroclor and congener concentrations, and for surface sediment samples with differences greater than five-fold, to determine whether a chemical interference or laboratory error could be identified. Although no obvious errors or consistent problems were identified, at least a portion of the differences between results could be attributed to one or more of the factors discussed above that commonly affect Aroclor quantification. These included chemical interferences, including TPH, PAHs, and DDx; the presence of multiple Aroclors, which affected the quantification of individual Aroclors; the presence of weathered PCBs with low chlorination levels that don't resemble an Aroclor; and PCB concentrations close to the reporting limit, where quantification is less precise than at higher concentrations. For most of these samples, however, these interferences did not appear to be sufficient to fully account for the large differences found between the total Aroclor and total PCB congener results. The differences are also likely to be the result of sample inhomogeneities related to the small-scale distribution of PCBs in the sediment, possibly including the presence of particles of materials such as paint, soot, or other organic particles, droplets, or colloids with associated PCBs.

Measurement error in Aroclor concentrations also increases the uncertainty of a linear regression prediction of congener concentrations (for example, in samples where only Aroclors were measured). This effect was examined and quantified using a simulation-extrapolation procedure detailed in Attachment D1.4.1.

D1.4.5 Conclusion

PCB congener data better represent total PCB concentrations than Aroclor data, as the congener method is less affected by "weathering," non-PCB interferences, and subjective Aroclor identifications. However, both methods represent the total PCB concentrations well, and measured total PCB concentrations are fairly comparable between methods in most cases (especially when measurement error is considered). Overall, results for total PCB congeners and Aroclors agreed within a factor of 2 for 72 percent of samples and within a factor of 4 for 90 percent of the samples. As the Portland Harbor SCRA database includes both total PCB congener results and total Aroclor results, it is useful to combine them to represent the spatial distribution of PCBs in the Study Area as fully as possible. In addition, the analysis of sediment data indicated that total Aroclor data overpredict total PCB congeners in concentrations below ~750 μg/kg total Aroclors and may result in underprediction above this threshold. Therefore, the use of Aroclor data to represent total PCBs will result in similar or more conservative site management decisions with a much larger spatial and temporal coverage than the use of congener data alone.

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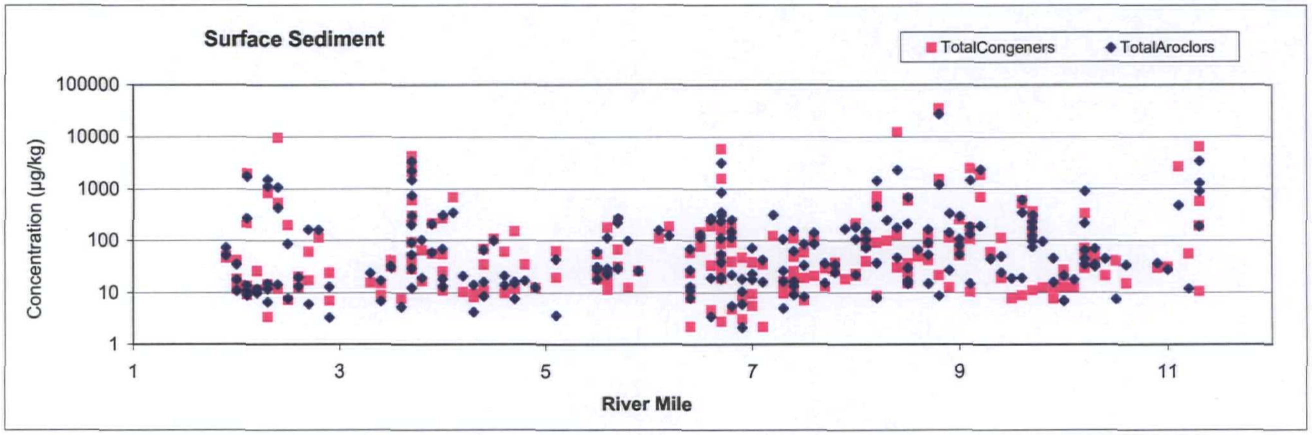
References in sediment data set/methods discussion are included in Section 5.1.3.



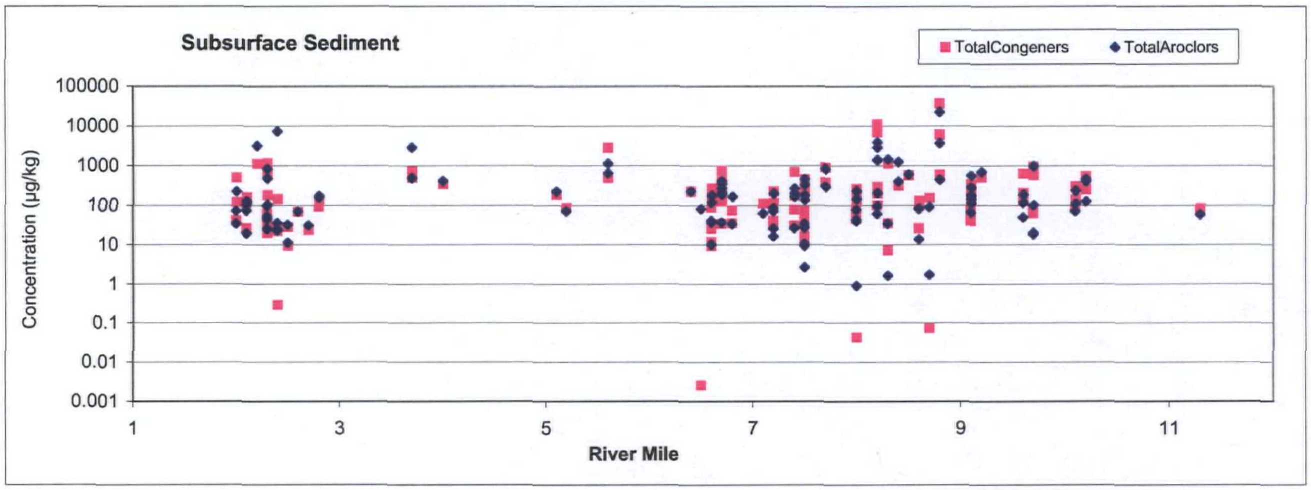


Figure D1.4-1a
Portland Harbor RI/FS
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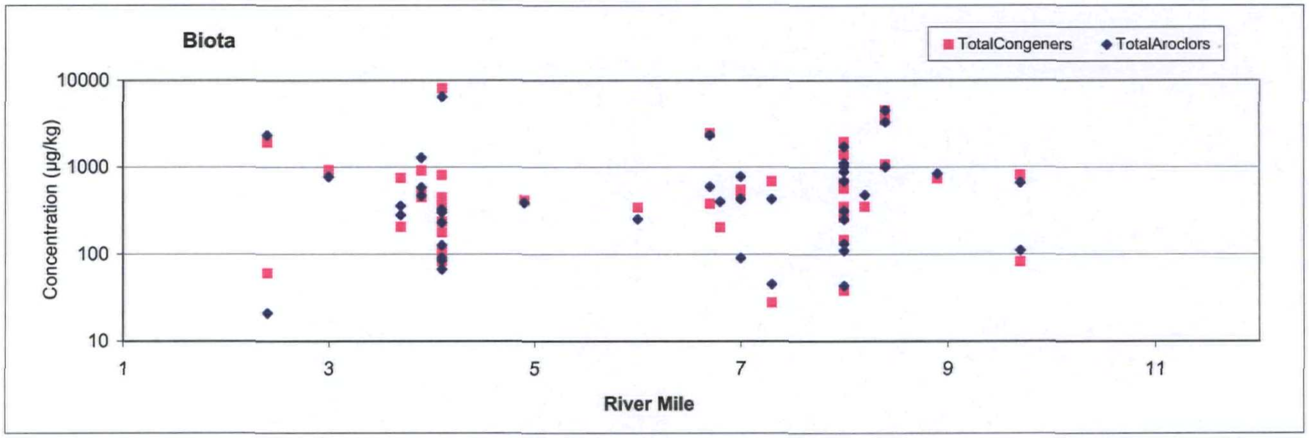
Scatter Plots of Total Aroclor and Total PCB Congener Concentrations
In Study Area Sediment, Biota, and Sediment Trap
Samples Analyzed by Both Methods



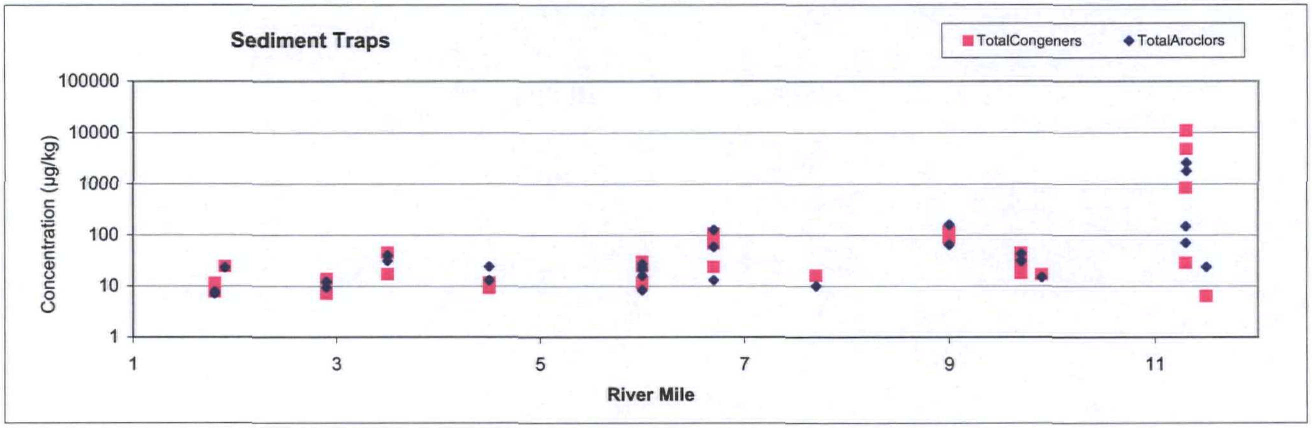


Figure D1.4-1b
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plots of Total Aroclor and Total PCB Congener Concentrations
In Study Area Sediment, Biota, and Sediment Trap
Samples Analyzed by Both Methods

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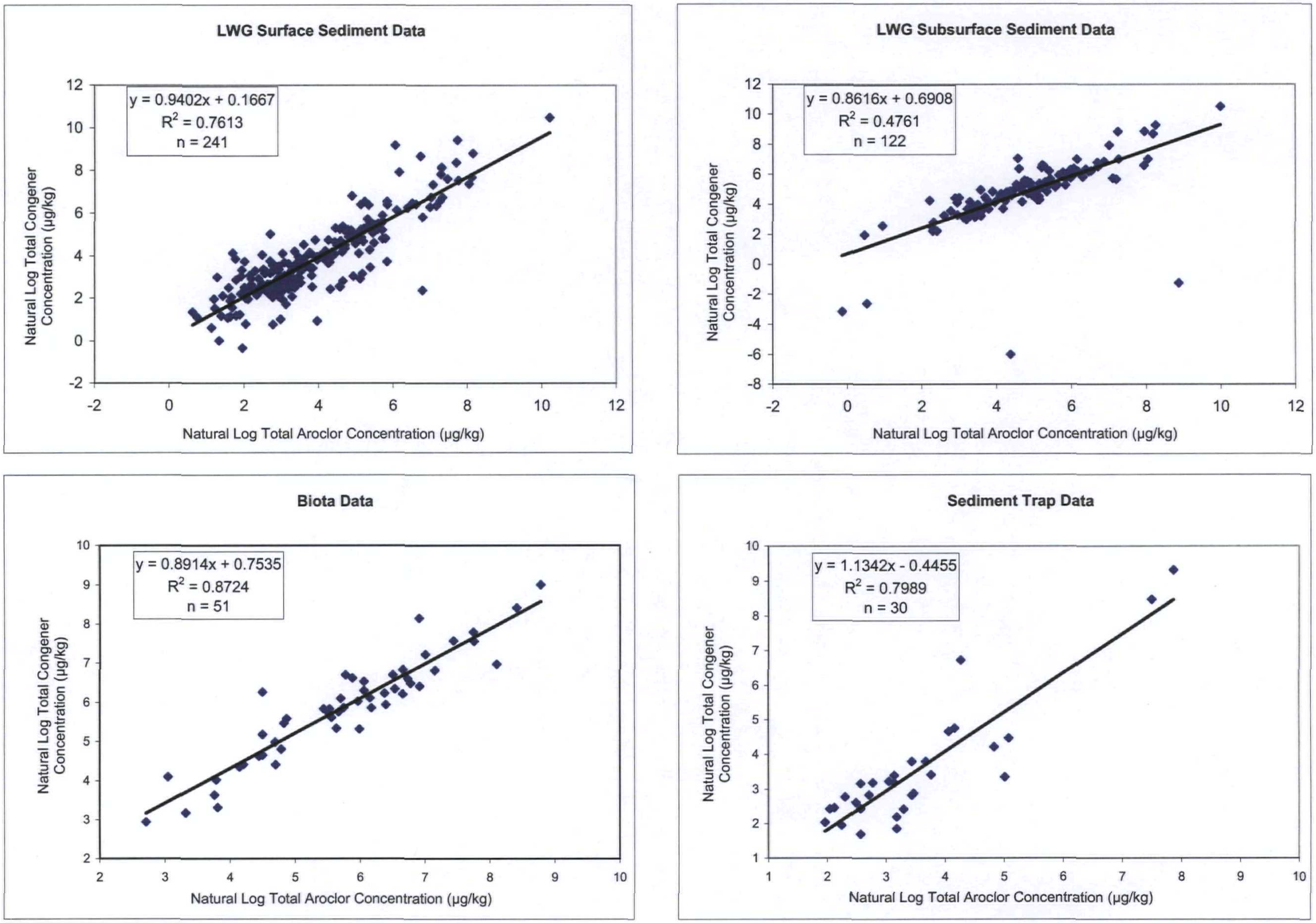

Figure D1.4-2
Portland Harbor RI/FS
Draft Remedial Investigation Report
Correlation of Aroclors and PCB Congeners in
Surface and Subsurface Sediment, Sediment Traps, and Biota

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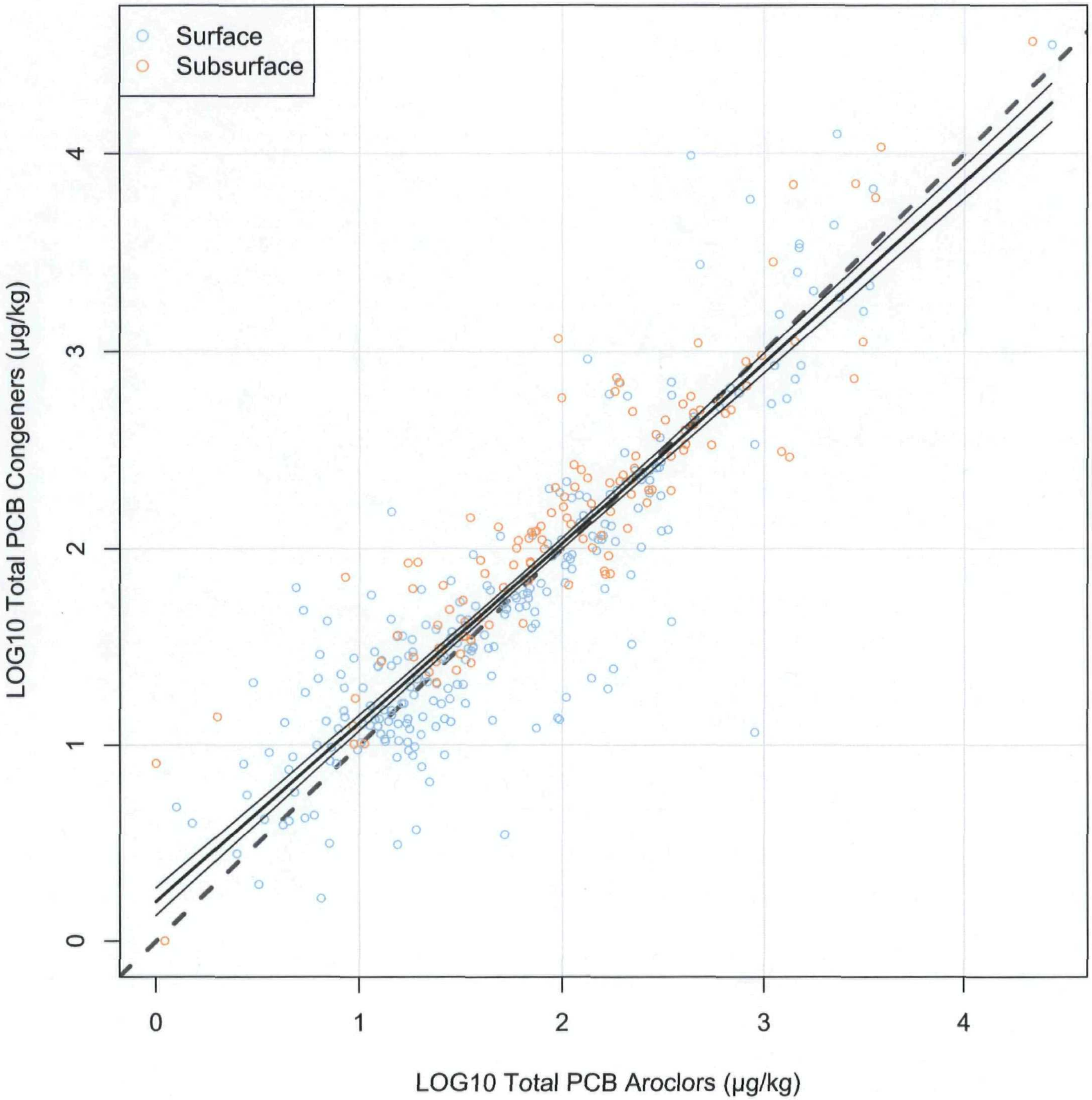


Figure D1.4-3
Portland Harbor RI/FS
Draft Remedial Investigation Report
Regression of Total PCB Congeners and Aroclors with 95% CI (solid lines) and the 1:1 line (dashed)

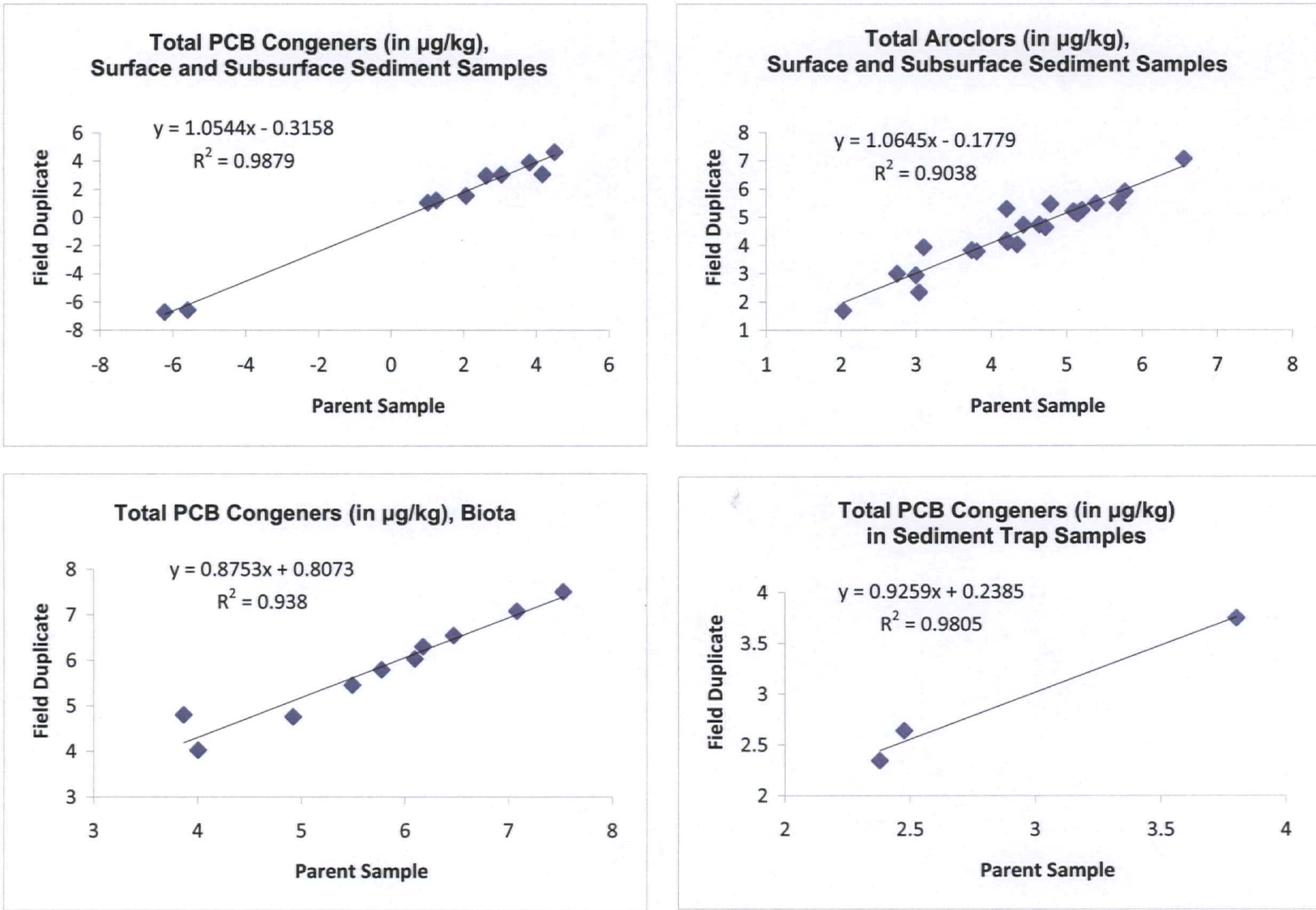
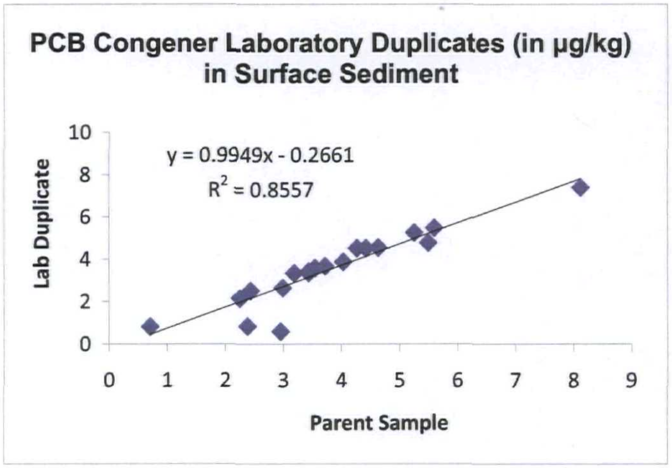
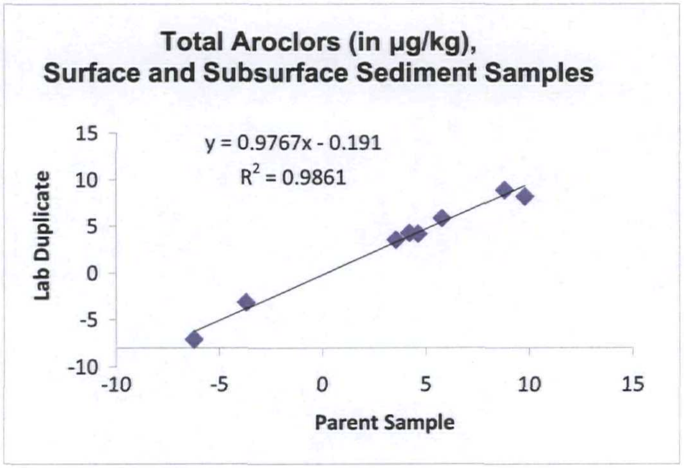
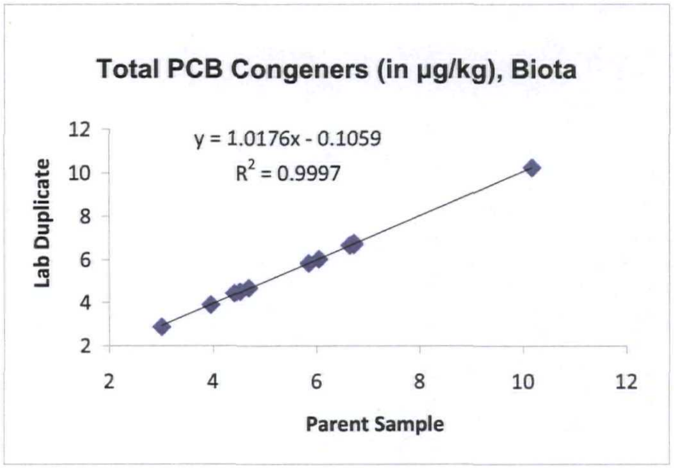


Figure D1.4-4
Portland Harbor RI/FS
Draft Remedial Investigation Report
Correlation of Total PCBs in Field Duplicate Samples







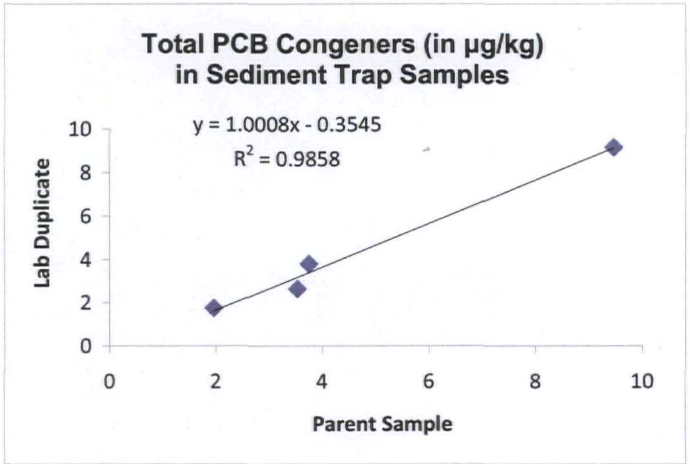


Figure D1.4-5a
Portland Harbor RI/FS
Draft Remedial Investigation Report
Correlation of Total PCBs in Laboratory
Duplicate and MS/MSD Samples

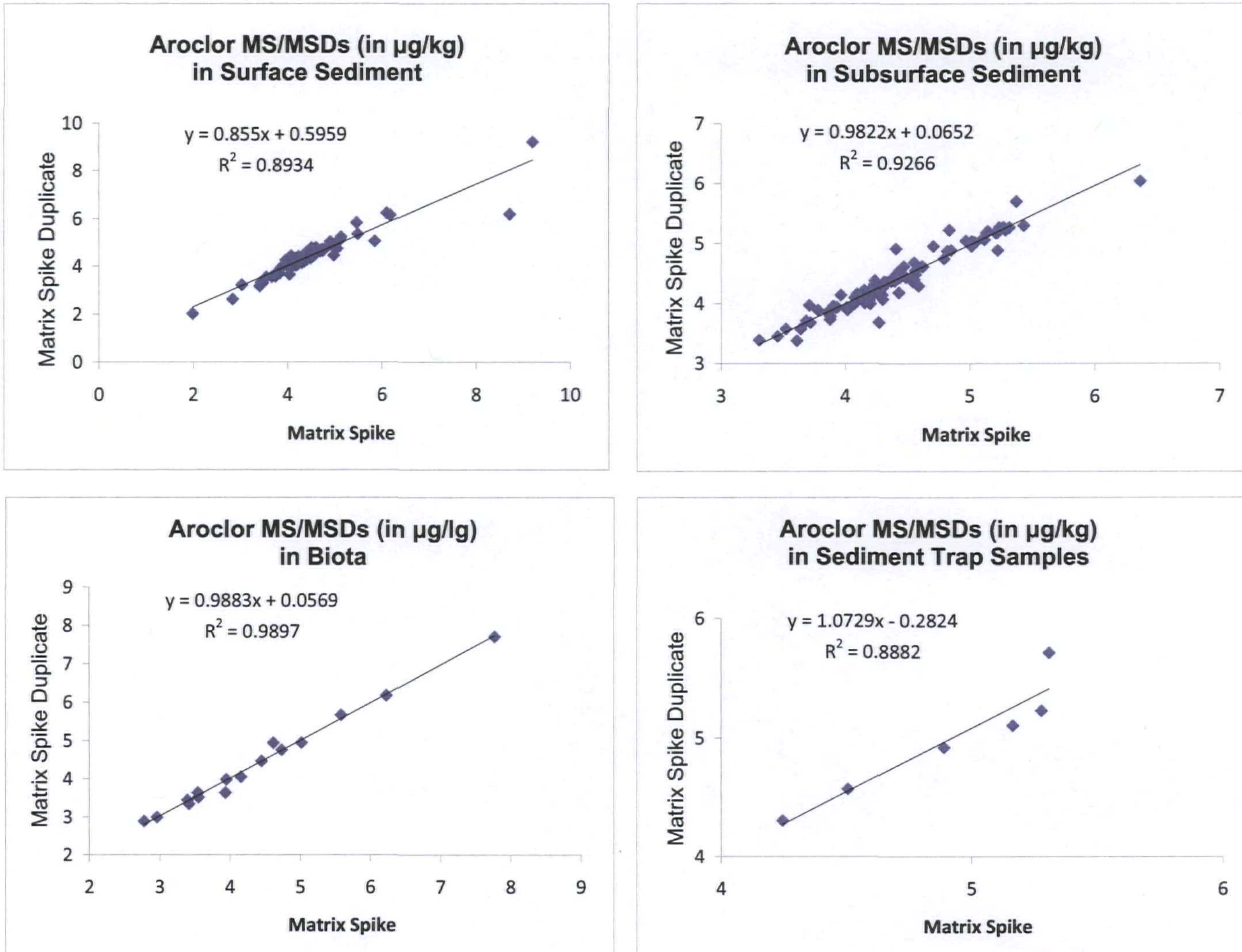


Figure D1.4-5b
Portland Harbor RI/FS
Draft Remedial Investigation Report
Correlation of Total PCBs in Laboratory Duplicate and MS/MSD Samples

Table D1.4-1. Samples with Greater Than Ten-Fold Difference Between Total Aroclor and Total PCB Congener Results.

Location	Sample ID	River Mile	Total Aroclors (µg/kg)	Total Congeners (µg/kg)
Surface Sediment				
G025	LW2-G025	2.4	432 T	9780 T
G147	LW2-G147	4.7	15.1 T	153 T
GCRSP11E	LW3-GCRSP11E	11.3	900 T	10.7 JT
GCA12W	LW3-GCA12W-C00	11.9	5.5 JT	62.5 JT
UG02C	LW3-UG02C	16.7	52.8 JT	2.57 JT
Subsurface Sediment				
C025-1	LW2-C025-C1	2.4	7170 JT	0.291 JT
C019-1	LW2-C019-C1	2.9	96.2 JT	1160 JT
C266	LW2-C266-C	6.5	79.5 JT	0.00252 JT
C703	LW3-C703-D	8	0.88 JT	0.0418 JT
C724	LW3-C724-E	8.7	1.7 JT	0.0719 JT
Sediment Trap Samples				
ST007	LW3-ST-2007	11.3	71 JT	840 T

Notes:

Qualifier Definitions:

J - The associated numerical value is an estimated quantity.

T - The associated numerical value was mathematically derived (e.g., from summing multiple analyte results such as Aroclors, or calculating the average of multiple results for a single analyte). Also indicates all results that are selected for reporting in preference to other available results (e.g., for parameters reported by multiple methods) for the Round 2 data.

PCB - polychlorinated biphenyl

Table D1.4-2. Summary of RPDs and Ratios for Total Aroclors and Total PCB Congeners in Field Samples and Field and Laboratory Duplicates.

Sample Type	Number of Samples	Maximum RPD [a]	Mean RPD [a]	Median RPD [a]	95th percentile	Minimum Ratio [b]	Maximum Ratio [b]	Mean Ratio [b]	Median Ratio [b]
Samples Analyzed by Both PCB Methods									
Total Aroclors and Total PCB Congeners									
Surface Sediment	241	195%	53%	41%	152%	0.044	84	1.9	1.1
Subsurface Sediment	122	200%	53%	45%	141%	0.083	31548	462	0.84
Biota	51	142%	35%	24%	100%	0.17	3.1	0.98	0.87
Sediment Trap Samples	30	169%	55%	51%	131%	0.085	5.2	1.3	0.88
Field Duplicates									
Total Aroclors									
Surface Sediment	16	79%	23%	13%	70%	0.50	2.3	1.1	1.0
Subsurface Sediment	11	199%	55%	29%	180%	0.11	331	31	1.1
Biota	--	--	--	--	--	--	--	--	--
Sediment Trap Samples	3	39%	--	--	--	0.68	1.2	--	--
Total PCB Congeners									
Surface Sediment	8	102%	27%	11%	84%	0.33	1.4	0.94	1.0
Subsurface Sediment	2	91%	--	--	--	0.37	0.61	--	--
Biota	10	88%	14%	5%	56%	0.85	2.58	1.16	1.01
Sediment Trap Samples	3	16%	--	--	--	0.95	0.96	--	--
Laboratory Precision									
Total Aroclors, MS/MSDs									
Surface Sediment	87	170%	13%	9%	37%	0.08	1.5	0.98	0.98
Subsurface Sediment	92	57%	9%	5%	32%	0.56	1.7	1.00	1.00
Biota	16	32%	9%	7%	30%	0.74	1.4	1.0	1.0
Sediment Trap Samples	6	40%	11%	6%	32%	0.94	1.5	1.1	1.0
Total PCB Congeners, Laboratory Duplicates									
Surface Sediment	19	166%	31%	12%	133%	0.094	1.3	0.86	0.94
Subsurface Sediment	9	130%	44%	43%	111%	0.21	1.7	0.90	1.0
Biota	11	11%	3%	2%	9%	0.90	1.1	1.0	1.0
Sediment Trap Samples	4	84%	36%	27%	76%	0.41	1.0	0.74	0.76

Notes:

[a] RPD is the difference between duplicate results divided by the average of the duplicate results, expressed as a percentage

[b] Ratio of the total Aroclor concentration to the total PCB congener concentration for samples analyzed by both methods; ratio of duplicate to parent sample for field and laboratory duplicates and MS/MSD.

MS/MSD - matrix spike/matrix spike duplicate
RPD - relative percent difference

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PORTLAND HARBOR RI/FS

REMEDIAL INVESTIGATION REPORT

APPENDIX D1.4, ATTACHMENT D1.4.1
MEMORANDUM ON PREDICTED CONGENER CONCENTRATIONS IN LOWER WILLAMETTE SURFACE SEDIMENTS

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October 27, 2009

TerraStat
CONSULTING GROUP

Quantitative Analysis for the Natural Sciences
10636 Sand Point Way NE
Seattle, WA 98125
206-362-3299

MEMORANDUM

To: Gene Revelas, Integral Consulting
From: Alice Shelly and Lorraine Read
Subject: Predicted Congener Concentrations in Lower Willamette Surface Sediments
Date: December 15, 2008

This memorandum describes the process we used to generate predicted total congener concentrations from sampled total Aroclor concentrations in surface sediments in the Lower Willamette River.

The sampled surface sediment total Aroclor and total congener concentrations are right-skewed, and the variance in the regression relationship increases with concentration (see Figure 1). Natural log transformations of both variables results in a clearly linear relationship with homogeneous variance (see Figure 2). Sometimes this model is not favored because of the lack of clarity as to proper back-transformation methods and the coverage of a back-transformed confidence limit. However, we believe this model provides the best fit to these data and will provide the best predictions for total congener concentrations for sites where only Aroclors were measured.

There are two issues that preclude simple linear regression predictions for these data: measurement error in total Aroclor concentrations and the back-transformation issue. Both of these issues result in bias to the predictions from the regression. We use the Simulation-Extrapolation (*Simex*; Cook and Stefanski, 1994) method to address measurement error, and the Bradu-Mundlak correction to eliminate back-transformation bias.

Naïve Model

The model for the linear least squares ln-ln regression is:

$$E(C) = 0.624A^{1.04}, \qquad \text{Eq. [1]}$$

where E(C) is the expected congener concentration for a given Aroclor concentration A ($R^2 = 0.78$).

Simex Model

Measurement error on the independent variable in a linear regression can result in serious bias to the estimated parameters. The *Simex* method as implemented in R (Lederer and Kuchenhoff, 2006) was used to correct for the measurement error in the reported Aroclor concentrations. An estimate of measurement error in the ln-transformed Aroclors is needed to estimate the Simex model. The variance of each available pair of lab sediment splits (ln-transformed concentrations) provides an estimate of measurement error for a particular Aroclor. We used the average of these variances for each Aroclor, then summed these variances to estimate the variance of the summed Aroclors. There were two Aroclors (out of seven) for which there were no splits, so we used the average of the five Aroclor variance estimates in the sum for these two Aroclors. The square root of this sum of variances is 0.47, the standard observation error needed as input to the Simex model.

The estimated Simex model is:

$$E(C) = 0.382A^{1.15}. \qquad \text{Eq. [2]}$$

The two models (naïve and Simex) are displayed in Figure 3.

<u>Bradu-Mundlak Correction</u>
When back-transformed, predictions from a log-linear model are biased estimates of the mean in original units. Because of this bias, the coverage of confidence or prediction intervals is also in question. We use the minimum-variance unbiased estimators (MVUEs) originally described by Finney (1941) and developed by Bradu and Mundlak (1970; See also Cohn et al, 1989), which can be implemented as a correction to the back-transformed parameters from the regression described above. This method is available in SAS, (Powell, 1991), but we wrote a script program for use in R. The formulas for the correction follow:

$$E(C) = (0.382A^{1.15}) * g(q), \qquad \text{Eq. [3]}$$

where

$$g(q) = \sum_{j=0}^{\infty} \left(\frac{m^j (m+2j)}{\prod_{i=0}^{j} (m+2i)} \right) * \left(\frac{q^j}{j!} \right) * \left(\frac{m}{m+1} \right)^j, \qquad \text{Eq. [4]}$$

$$q = \left(\frac{m+1}{2m} \right) * \left(s^2 - \hat{\sigma}^2_{\hat{C}_h} \right), \qquad \text{Eq. [5]}$$

m = the degrees of freedom from the regression (219),

s^2 = the MSE from the Simex regression (0.651),

$\hat{\sigma}^2_{\hat{C}_h} = s^2 \left[1 + \frac{1}{n} + \frac{(A_h - \overline{A})^2}{\sum_{i=1}^{n} (A_i - \overline{A})^2} \right]$ is the variance of $\hat{C}_h$, the predicted ln-congener concentration at ln-Aroclor concentration (A_h), and n = 221.

The prediction limits for an unbiased estimate of the mean in original units, (i.e., E(C), given by Eq. [3]), are then given by:

$$\left[E(C)*\exp(t_{.975,m}*\hat{\sigma}_{\hat{C}_h}),\ E(C)*\exp(t_{.975,m}*\hat{\sigma}_{\hat{C}_h})\right] \quad \text{Eq. [6]}$$

The resulting predictions and prediction intervals are displayed in Figure 4 and provided in the attached excel spreadsheet.

References

Bradu, D., and Y. Mundlak (1970). Estimation in lognormal linear models. Journal of the American Statistical Association 65:198-211.

Cohn, Timothy A., Lewis L. DeLong, Edward J. Gilroy, Robert M. Hirsch, and Deborah K. Wells (1989). Estimating constituent loads. Water Resources Research, 25(5):937-942.

Cook, J.R. and Stefanski, L.A. (1994) Simulation-Extrapolation estimation in parametric measurement error models. Journal of American Statistical Association, 89:1314-1328.

Finney, D.J. (1941). On the distribution of a variate whose logarithm is normally distributed. Journal of the Royal Statistical Society (supplement), 7:155-161.

Lederer, Wolfgang, and Helmut Küchenhoff (2006). A short Introduction to the SIMEX and MCSIMEX. R-news. Vol. 6/4, October 2006. http://www.stat.uni-muenchen.de/~helmut/r-news_WL_HK.pdf.

Powell, S. (1991) Implementation in the SAS System of the Bradu-Mundlak minimum variance unbiased estimator of the mean of a lognormal distribution. In "Proceedings of the 16th Annual SAS Users Group International Conference", pp. 1745. SAS Institute, Inc., Cary, NC.

Powell, S. (2002). Interagency Memo to Janet Spencer from Sally Powell, Senior Environmental Research Scientist, Department of Pesticide Regulation, California EPA. January 8, 2002. "Equations for predicted values and prediction limits for dislodgeable foliar residues" (http://www.cdpr.ca.gov/docs/whs/memo/hsm02001)

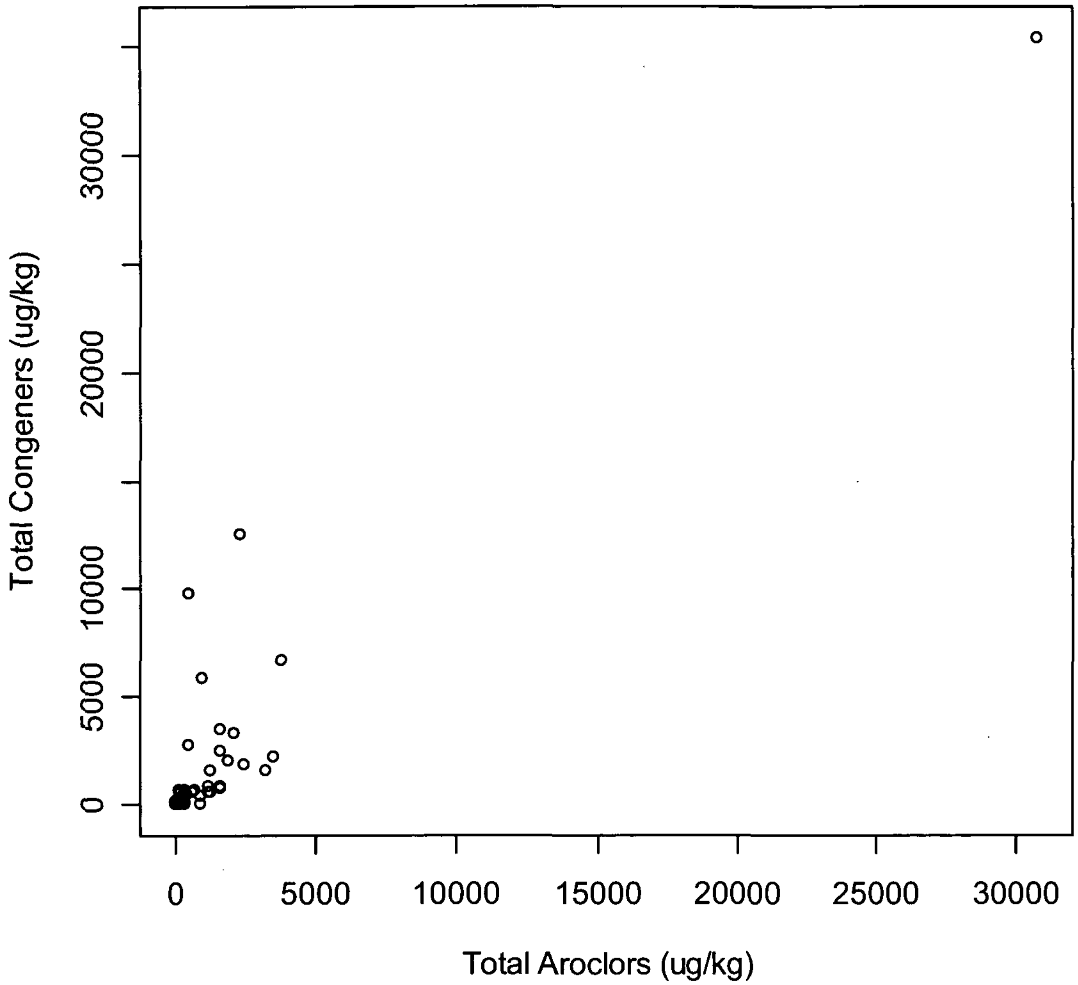

Figure 1. Measured total Aroclors vs. total congeners in surface sediments on the Lower Willamette River.

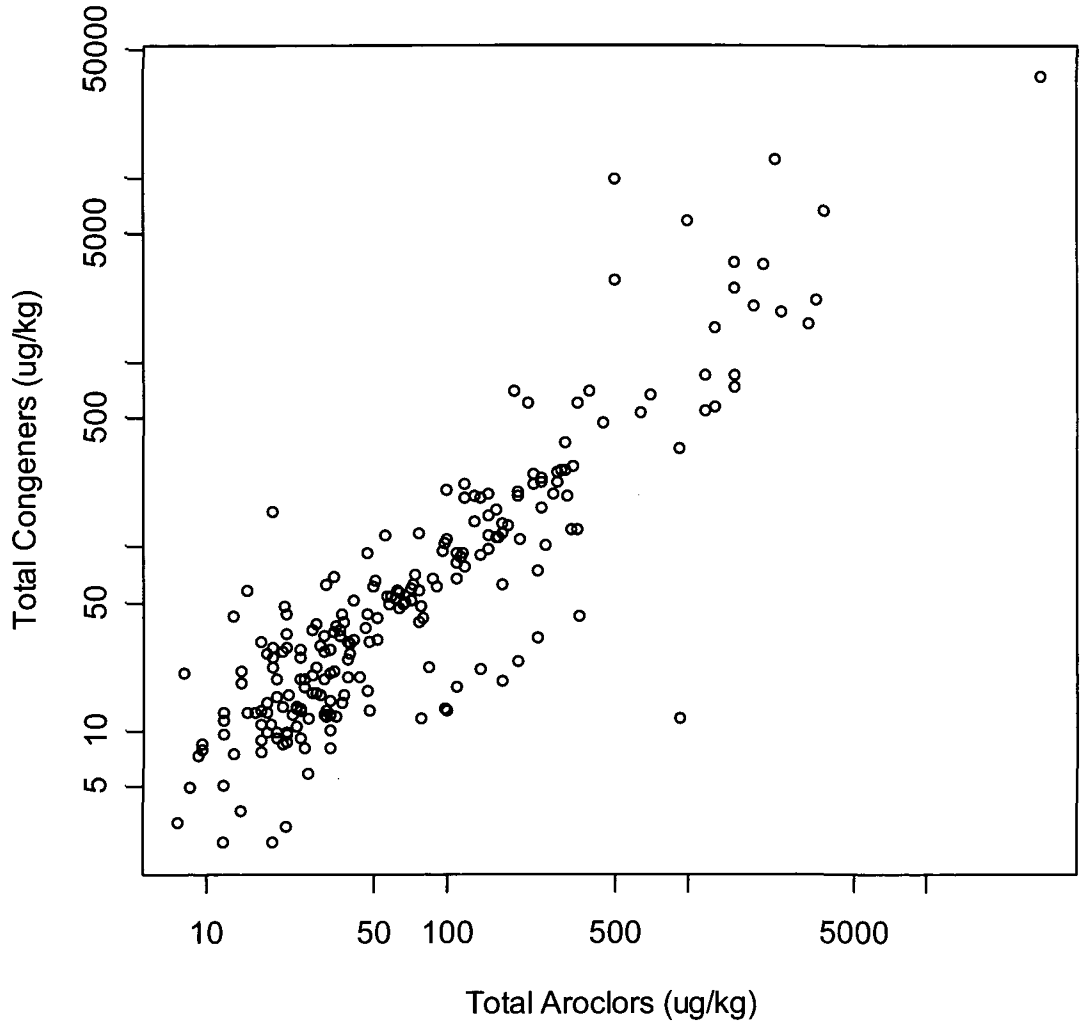

Figure 2. Total congeners as a function of total Aroclors with both variables on the log-scale.

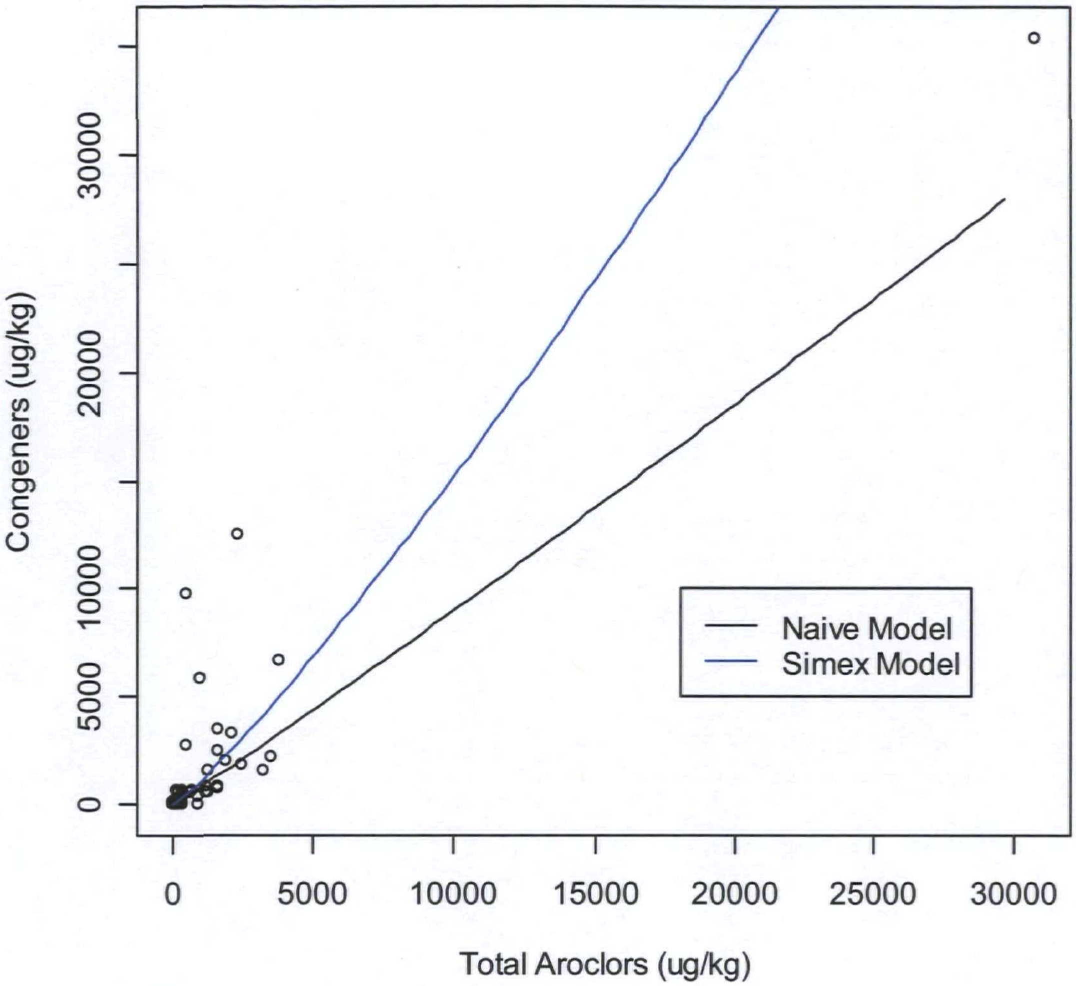

Figure 3. Naïve and Simex models compared.

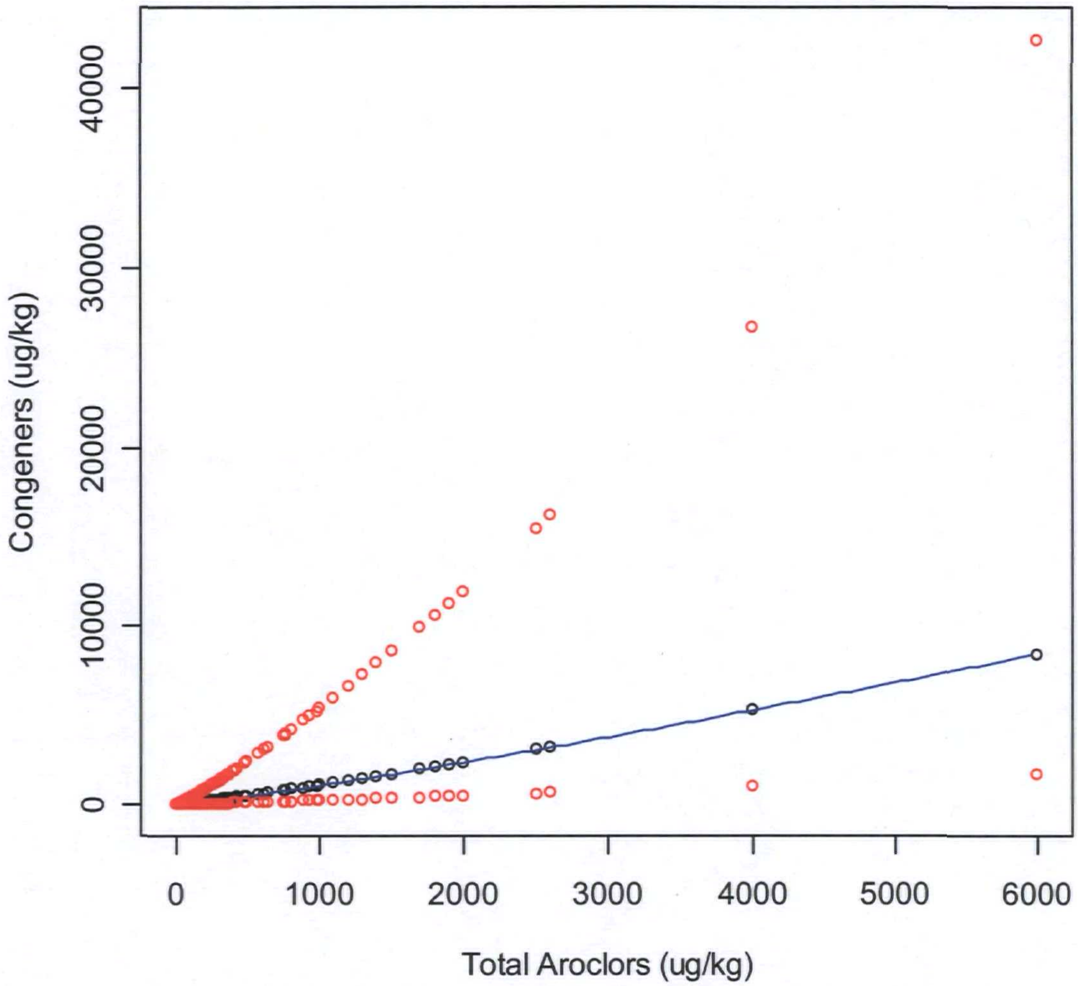

Figure 4. Bias-corrected MVUE predictions from the Simex model with 95% prediction intervals. The blue line is the Simex model fit. The black circles are the bias corrected predictions, and the orange circles are the upper and lower prediction limits.

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REMEDIAL INVESTIGATION REPORT

APPENDIX D1.5
DERIVED SUMS FOR ALL MEDIA
(ON CD)

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APPENDIX D2
IN-RIVER SEDIMENT TRAPS

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Appendix D2.1

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REMEDIAL INVESTIGATION REPORT

APPENDIX D2.1
SEDIMENT TRAP INDICATOR CHEMICAL, PERCENT FINES, AND TOTAL ORGANIC CARBON HISTOGRAMS (FOR ICS NOT PRESENTED IN MAIN REPORT)

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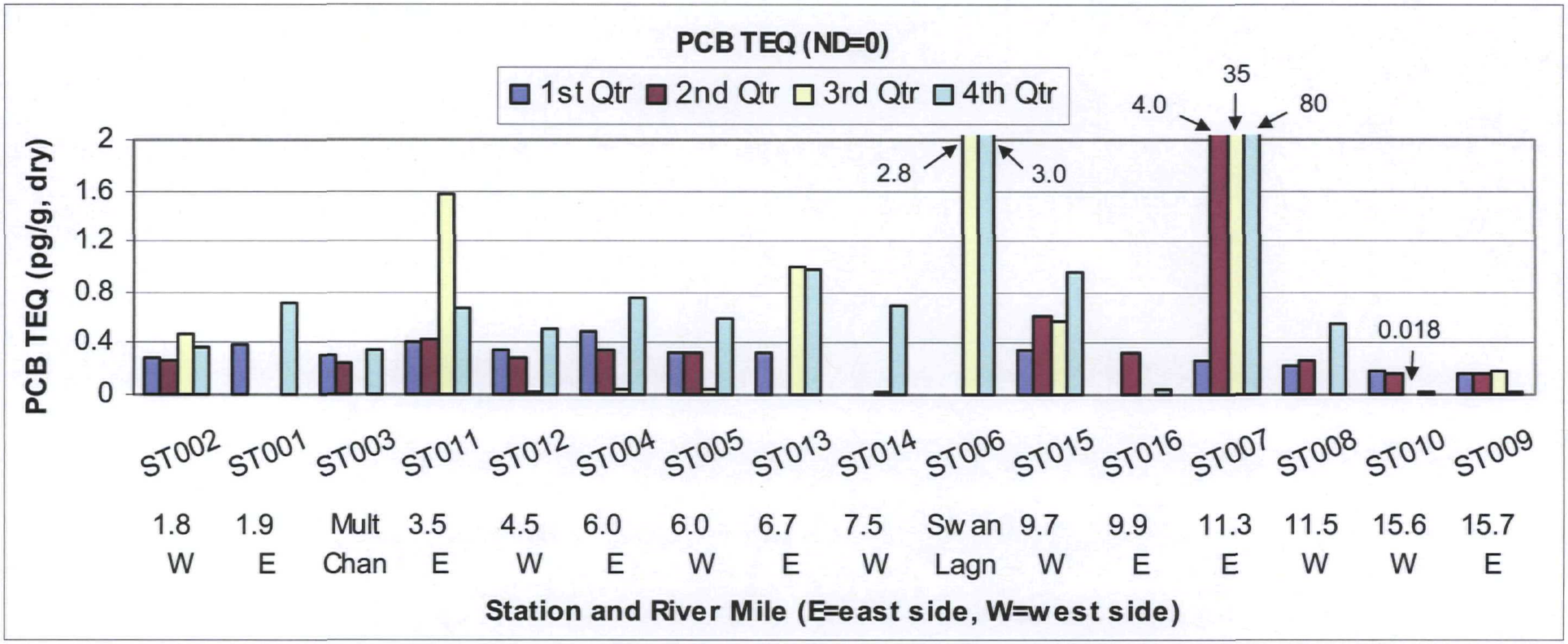
October 27, 2009

LIST OF FIGURES



Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.

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Figure D2.1-1
Portland Harbor RI/FS
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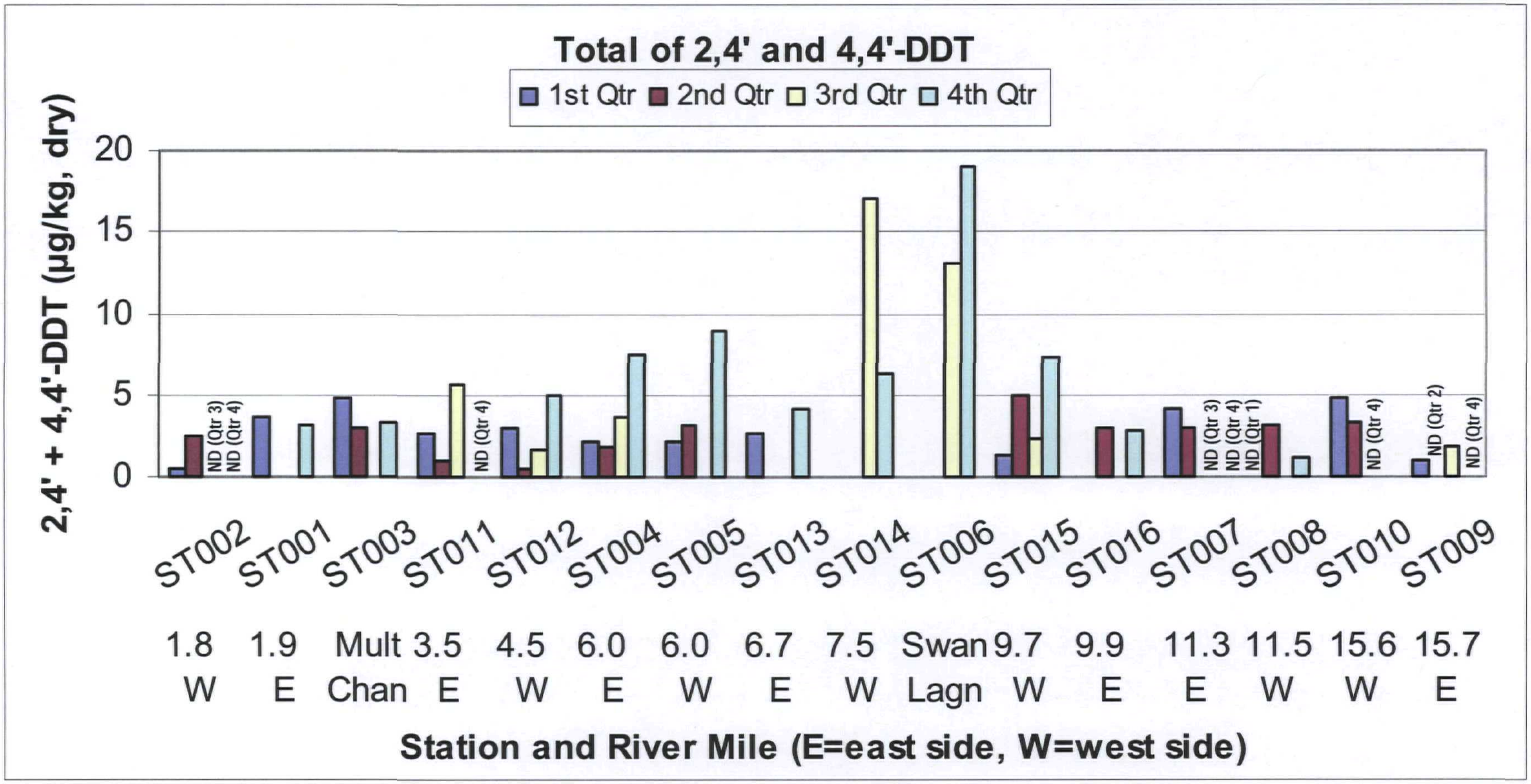
Histogram of PCB TEQ (ND=0)
Concentrations for In-River Sediment Traps



Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.
ND=not detected at quarter shown

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Figure D2.1-2
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total of 2,4'- and 4,4'-DDT
Concentrations for In-River Sediment Traps

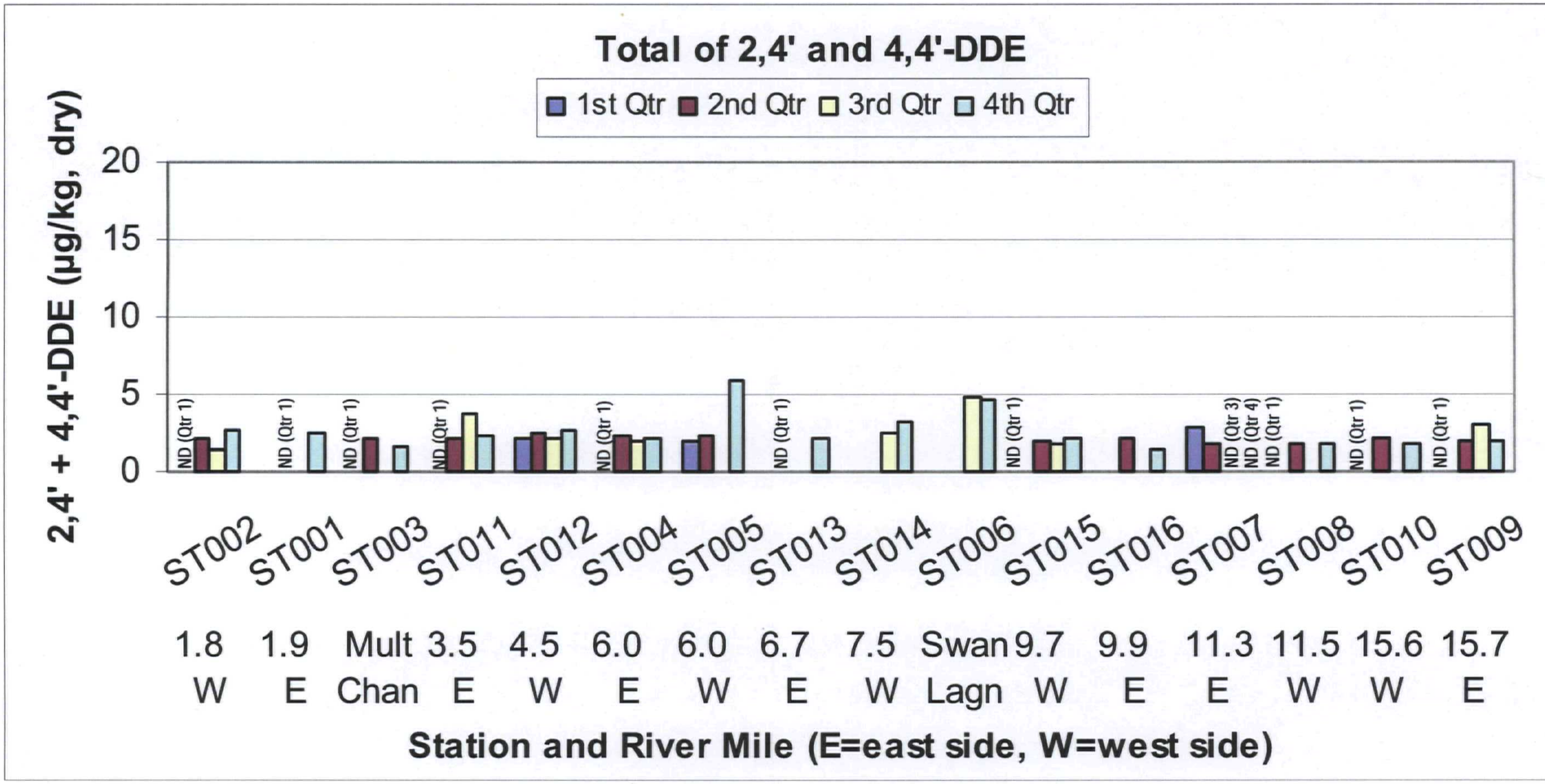

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Figure D2.1-3
Portland Harbor RI/FS
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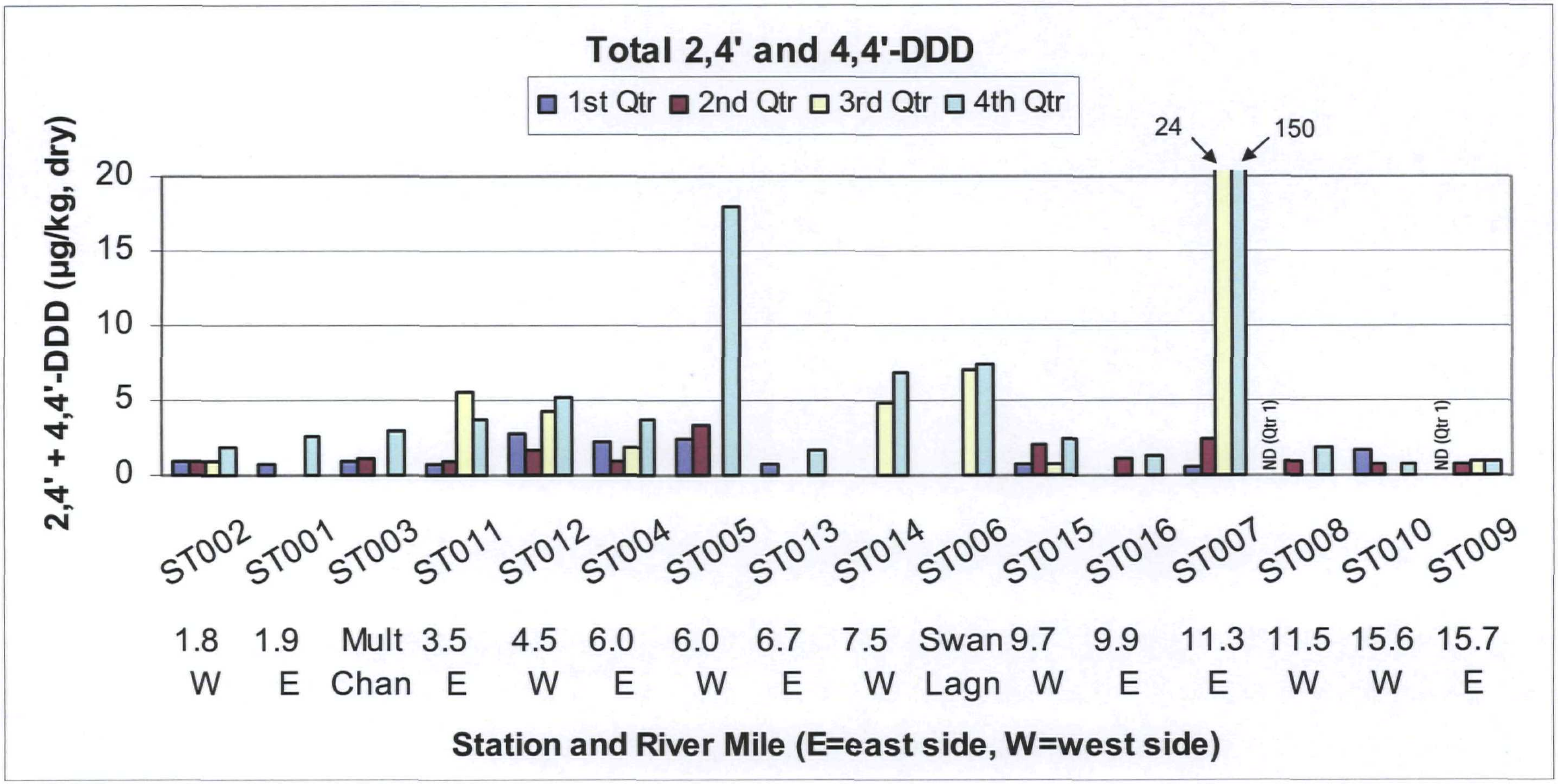
Histogram of Total of 2,4' and 4,4'-DDE
Concentrations for In-River Sediment Traps



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ND=not detected at quarter shown

Figure D2.1-4
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total of 2,4' and 4,4'-DDD
Concentrations for In-River Sediment Traps

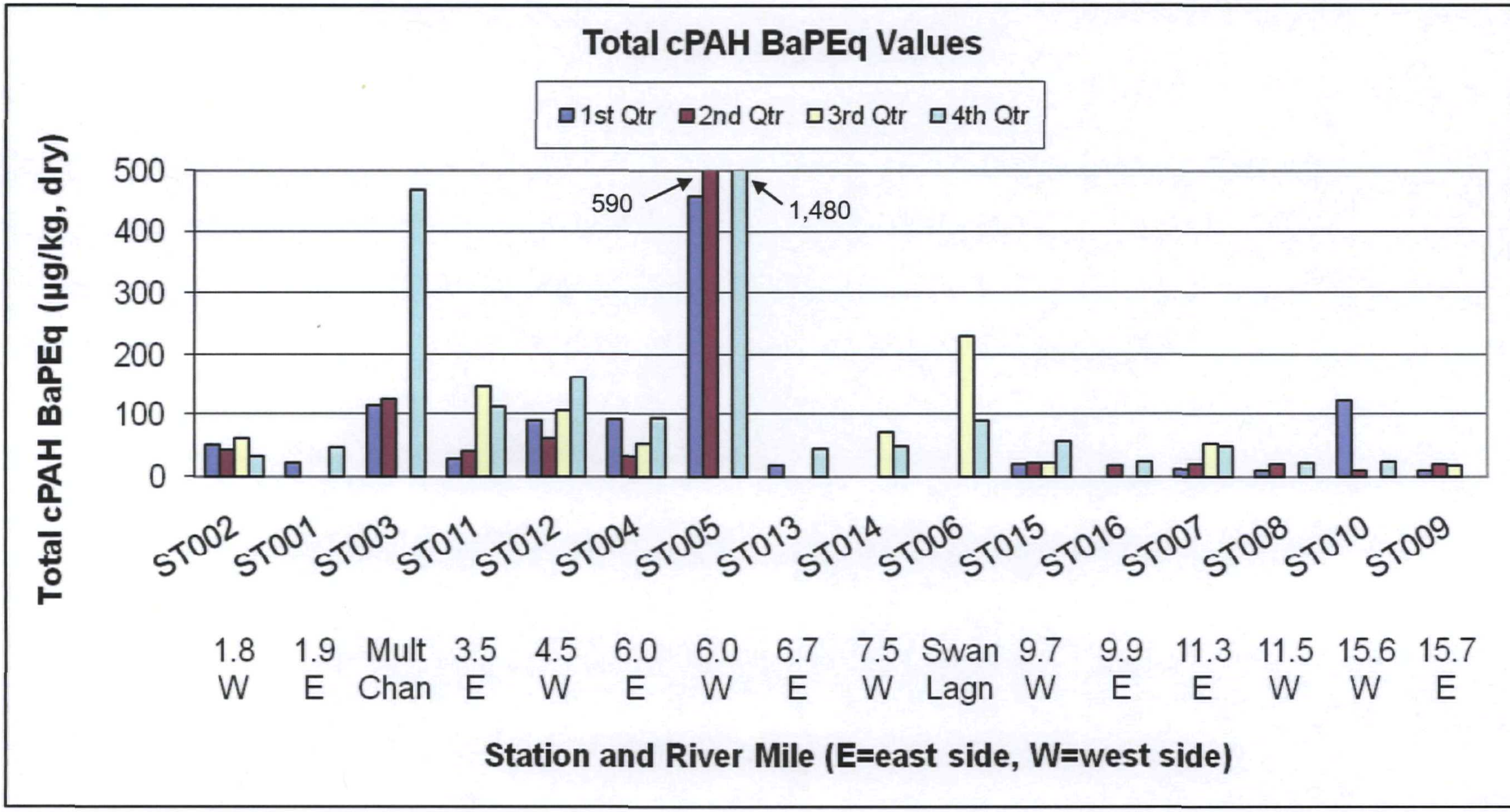

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Figure D2.1-5
Portland Harbor RI/FS
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Histogram of Total cPAH BaPEq Values
Concentrations for In-River Sediment Traps

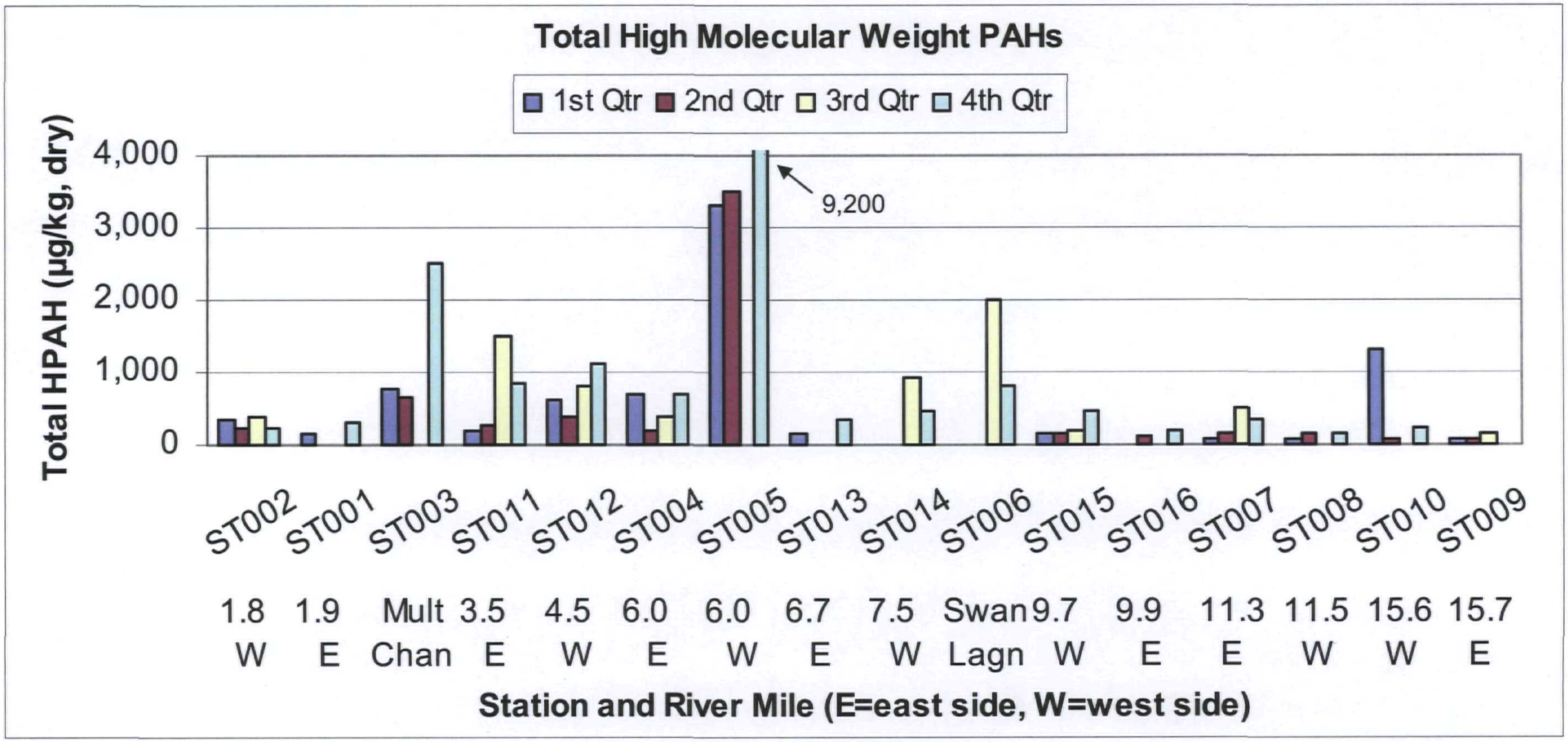

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Figure D2.1-6
Portland Harbor RI/FS
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Histogram of Total High Molecular Weight PAH Concentrations for In-River Sediment Traps

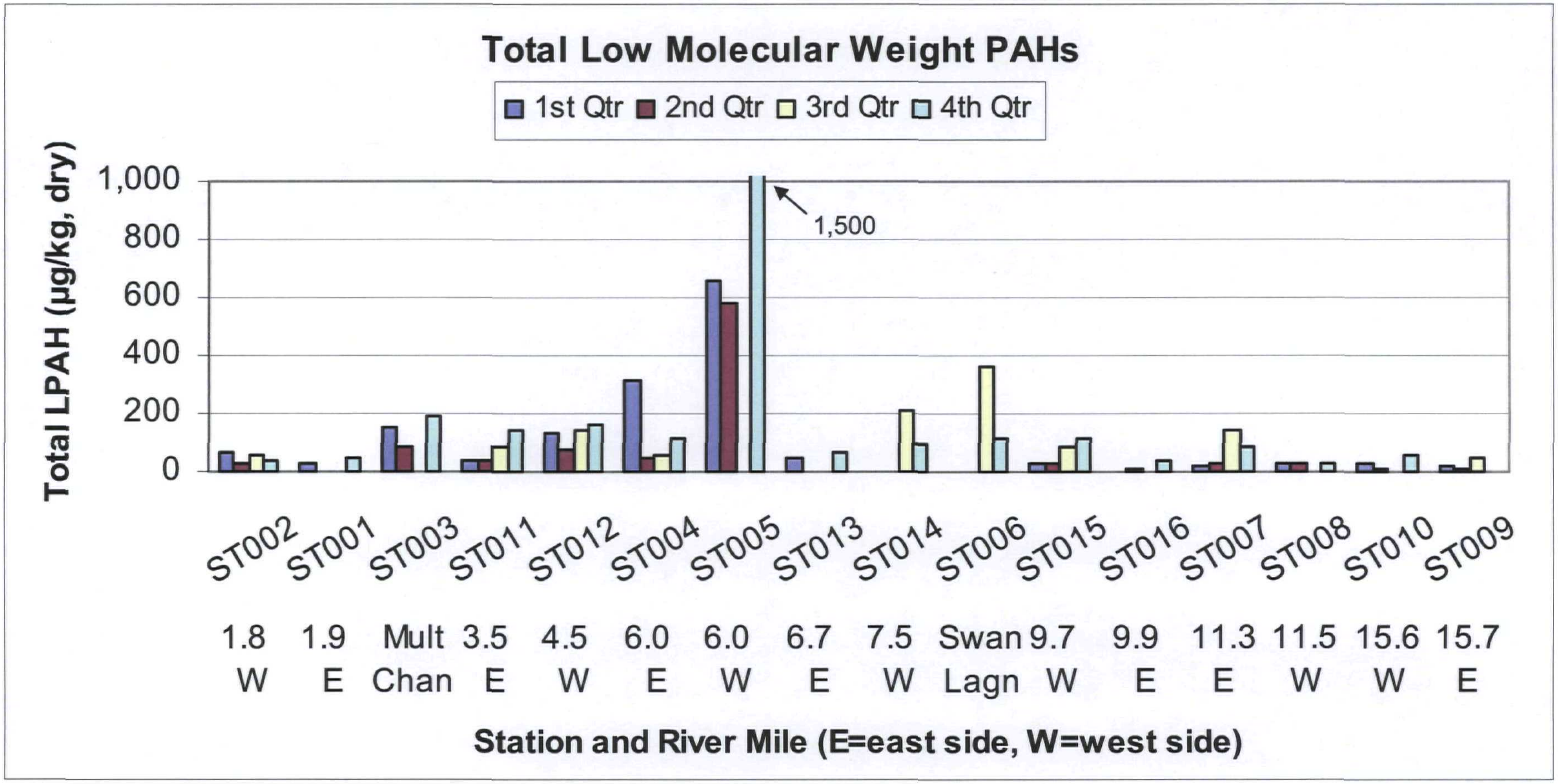

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Figure D2.1-7
Portland Harbor RI/FS
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Histogram of Total Low Molecular Weight PAH Concentrations for In-River Sediment Traps

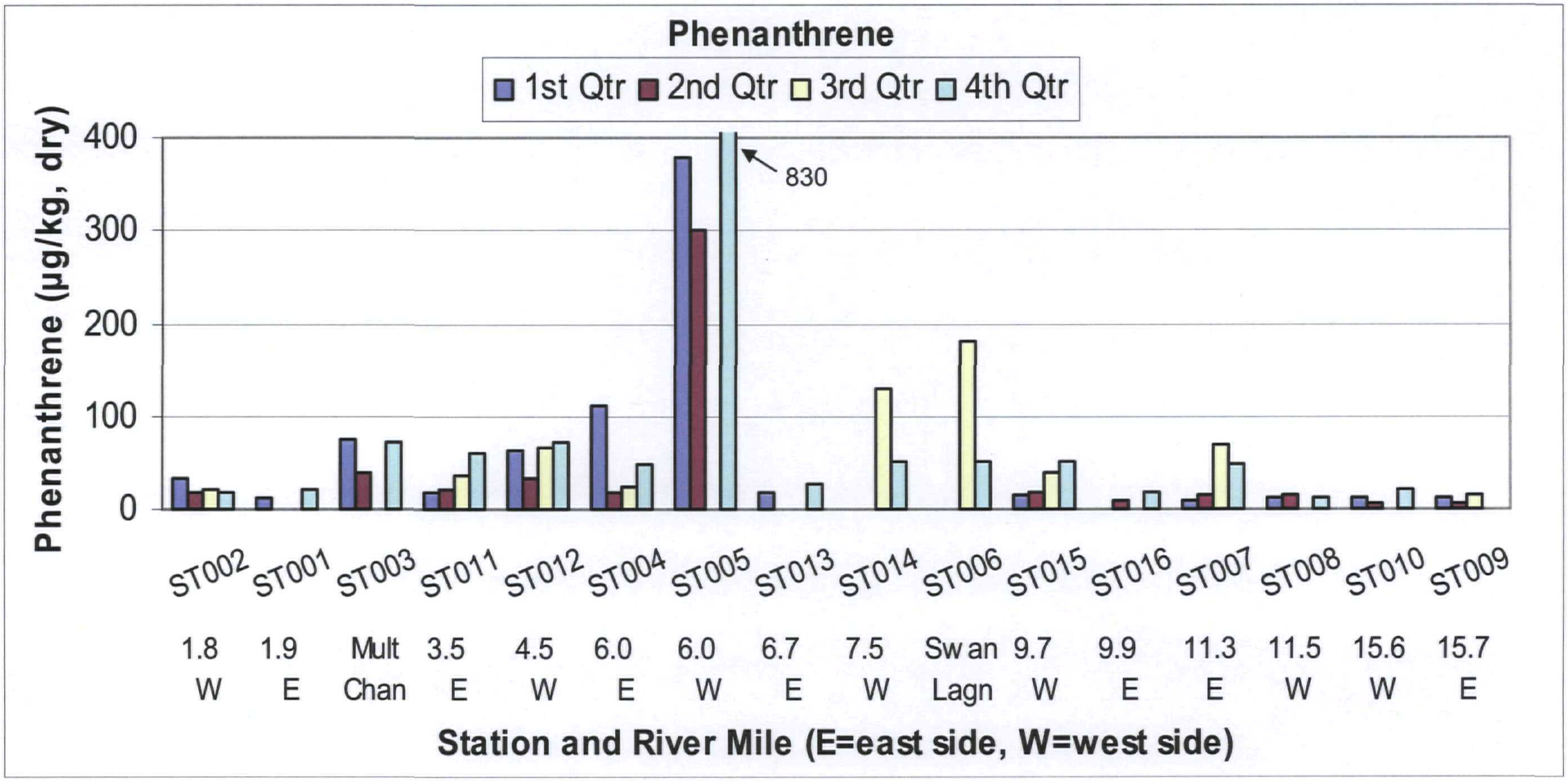

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Figure D2.1-8
Portland Harbor RI/FS
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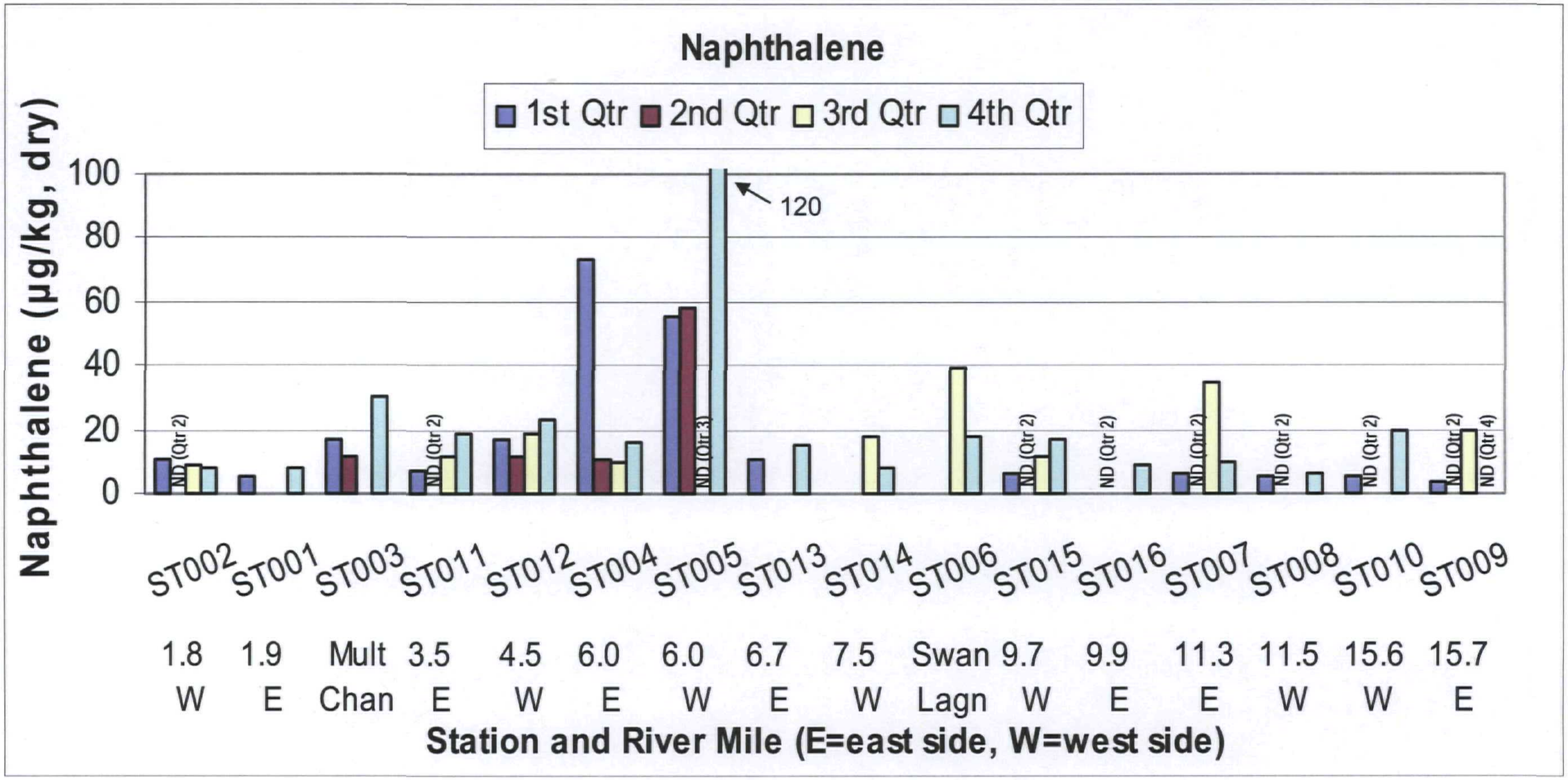
Histogram of Phenanthrene
Concentrations for In-River Sediment Traps



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ND=not detected at quarter shown

Figure D2.1-9
Portland Harbor RI/FS
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Histogram of Naphthalene
Concentrations for In-River Sediment Traps

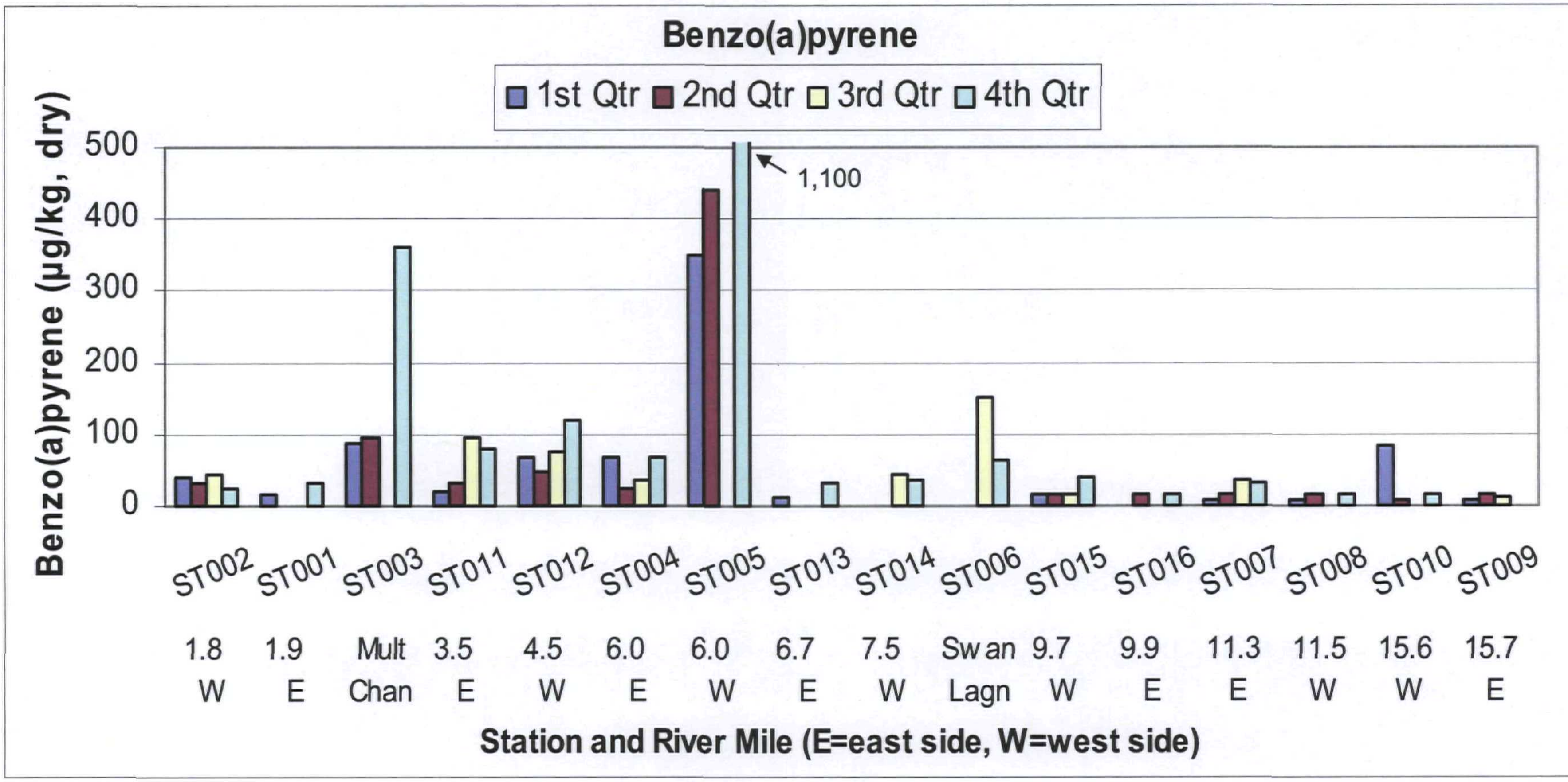

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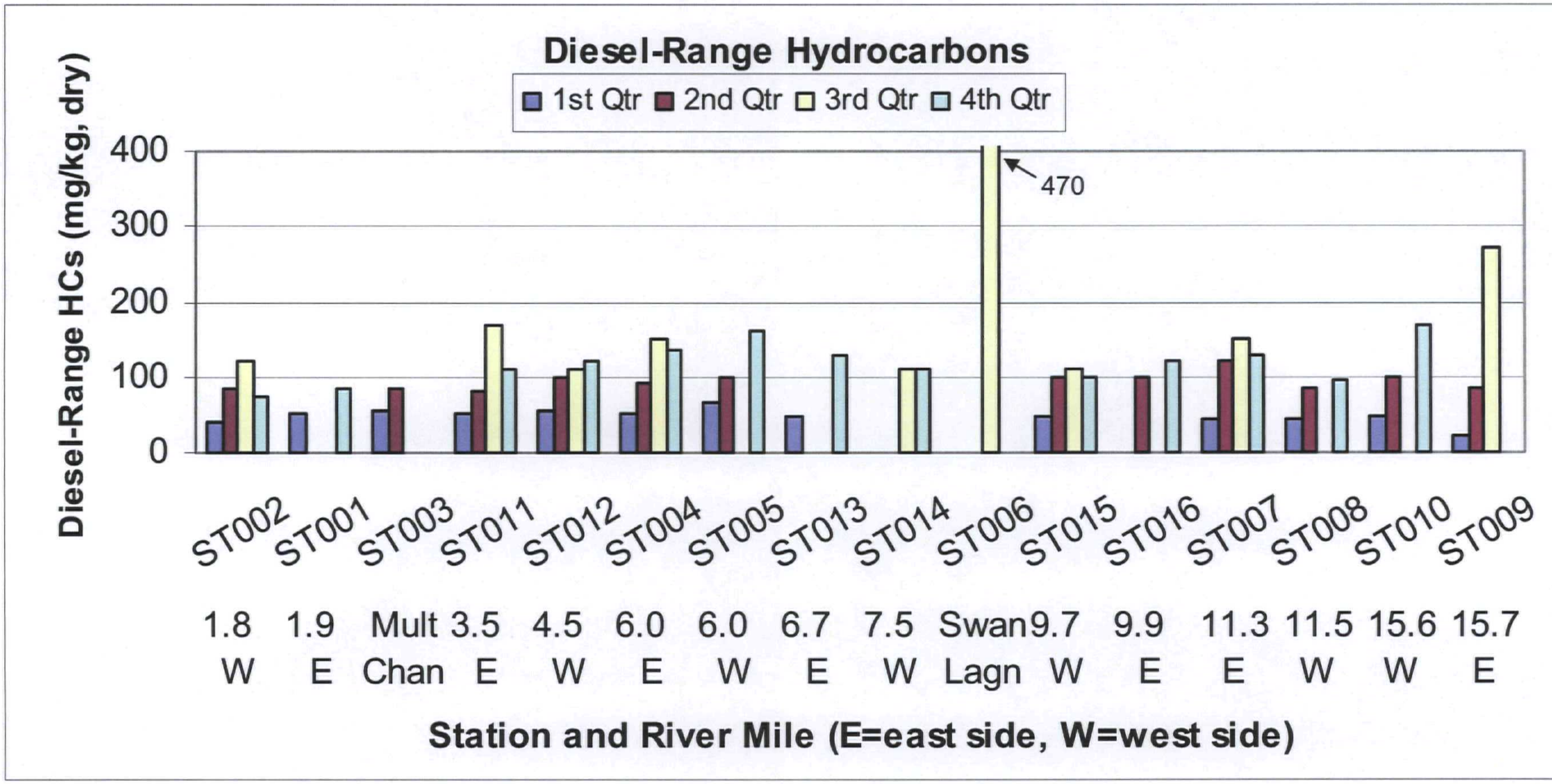
Figure D2.1-10
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Benzo(a)pyrene
Concentrations for In-River Sediment Traps



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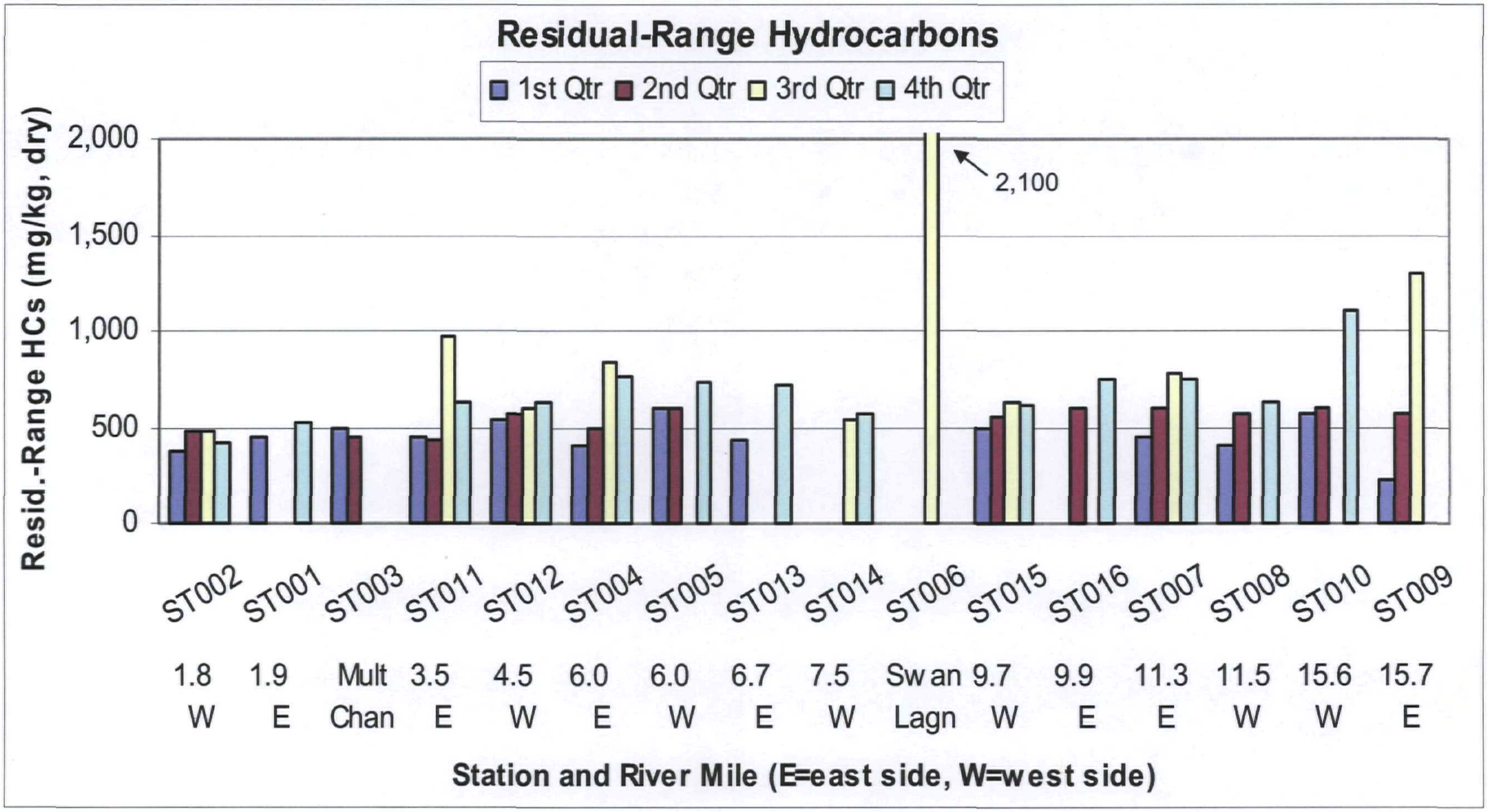
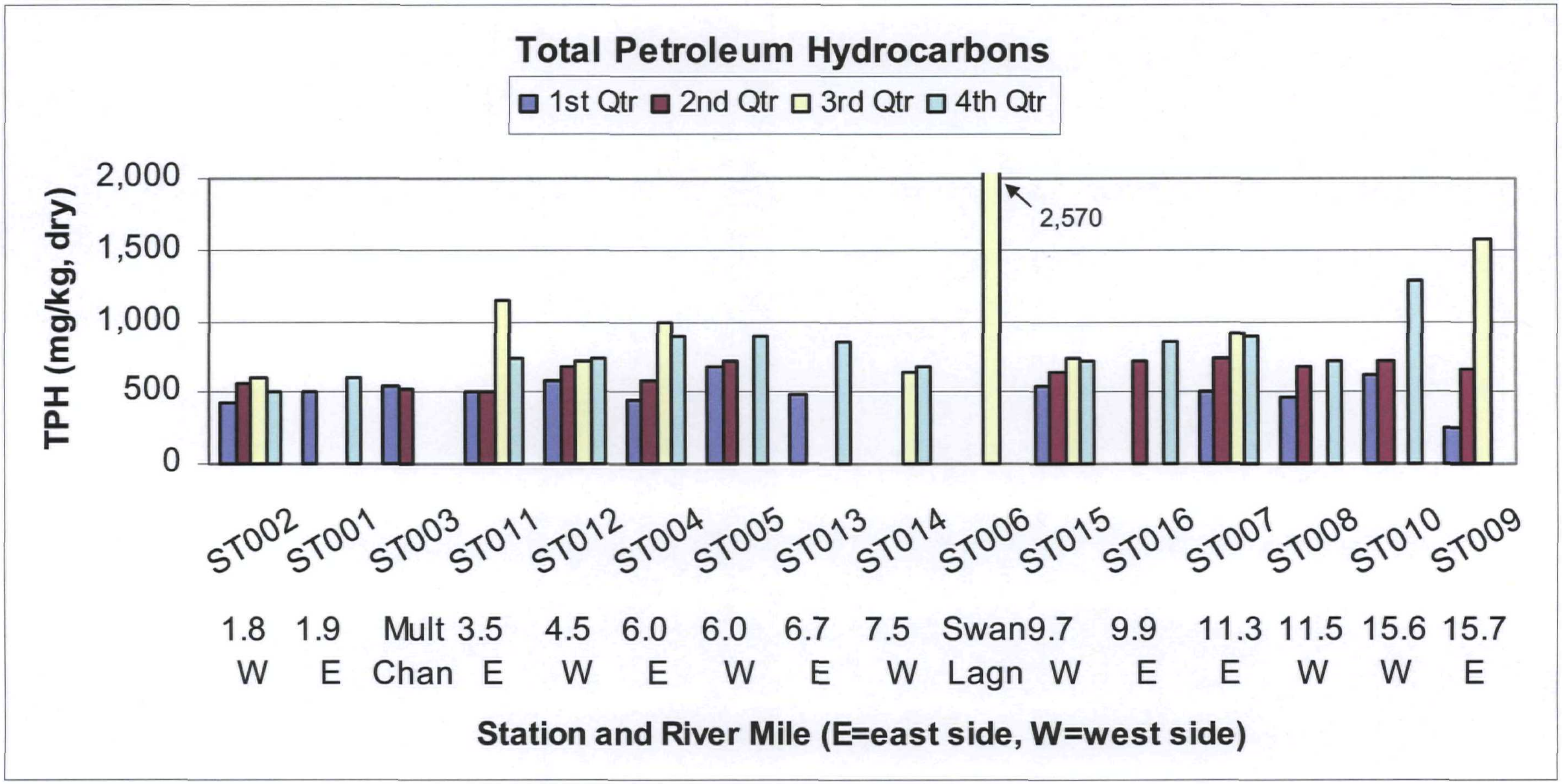
Draft Remedial Investigation Report
Histogram of Diesel-Range Hydrocarbon Concentrations for In-River Sediment Traps



Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.

Figure D2.1-12
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Residual-Range Hydrocarbon Concentrations for In-River Sediment Traps



Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.

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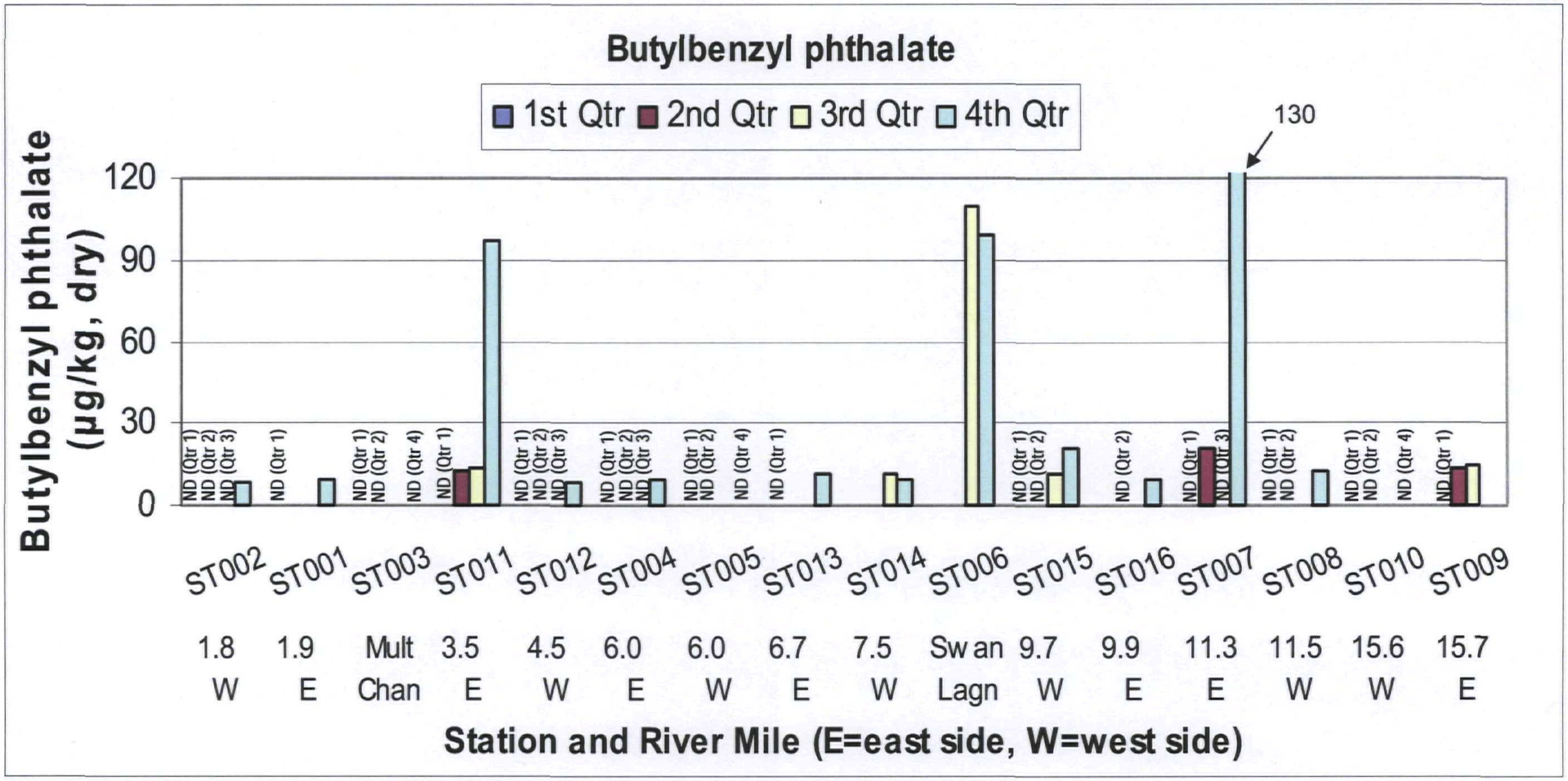
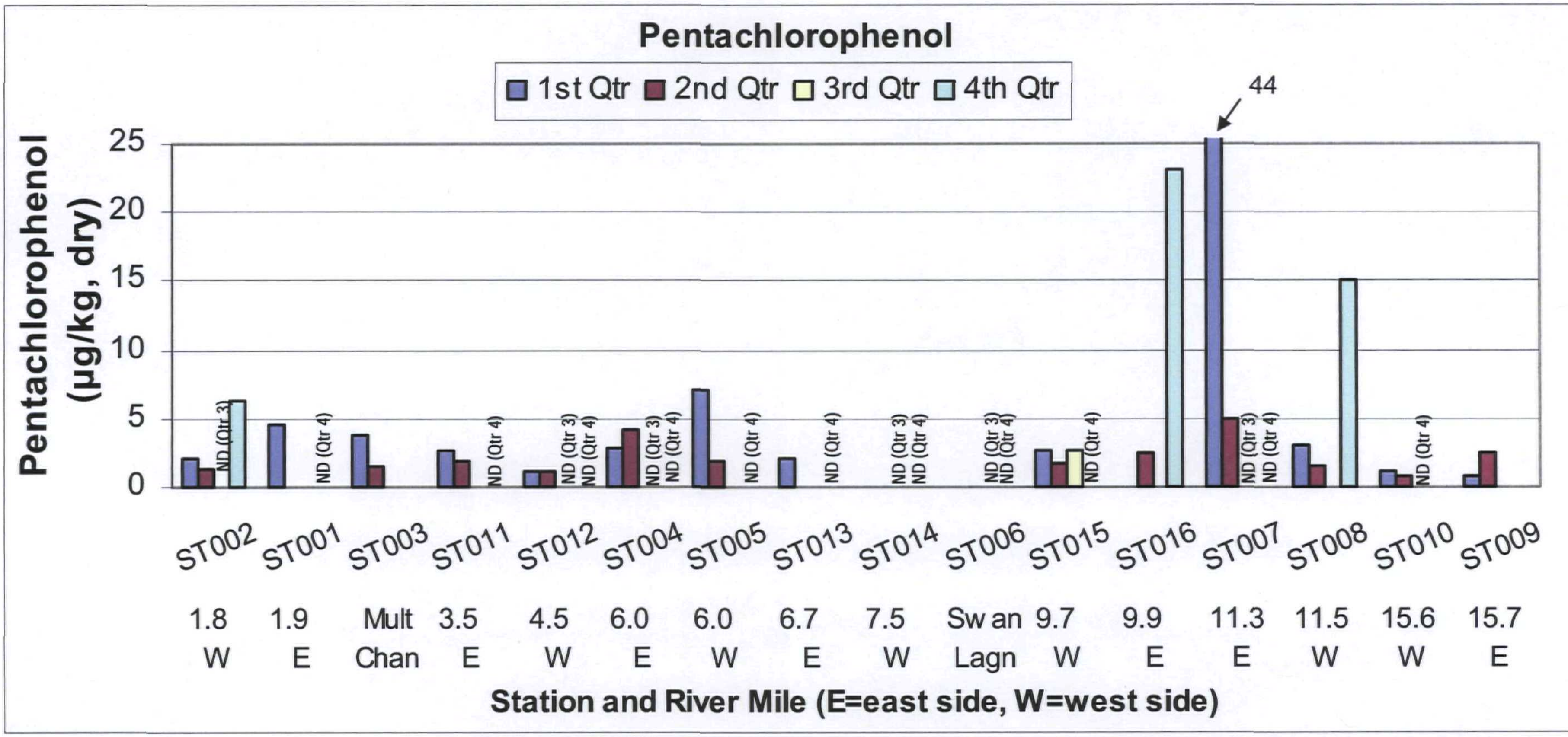
Figure D2.1-13
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total Petroleum Hydrocarbon Concentrations for In-River Sediment Traps



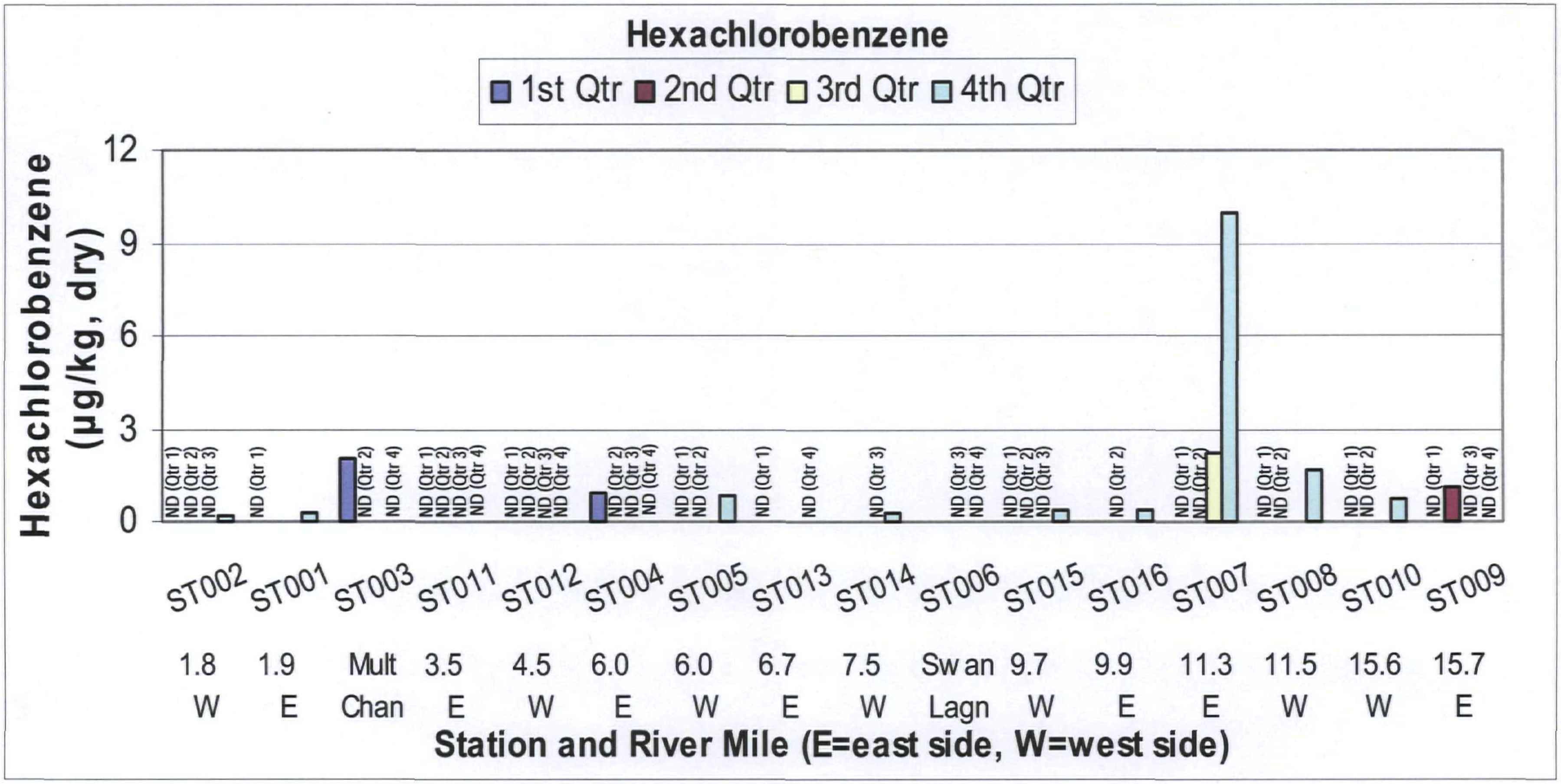
Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.

ND=not detected at quarter shown



Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.
ND=not detected at quarter shown

Figure D2.1-15
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Pentachlorophenol
Concentrations for In-River Sediment Traps



Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.
ND=not detected at quarter shown

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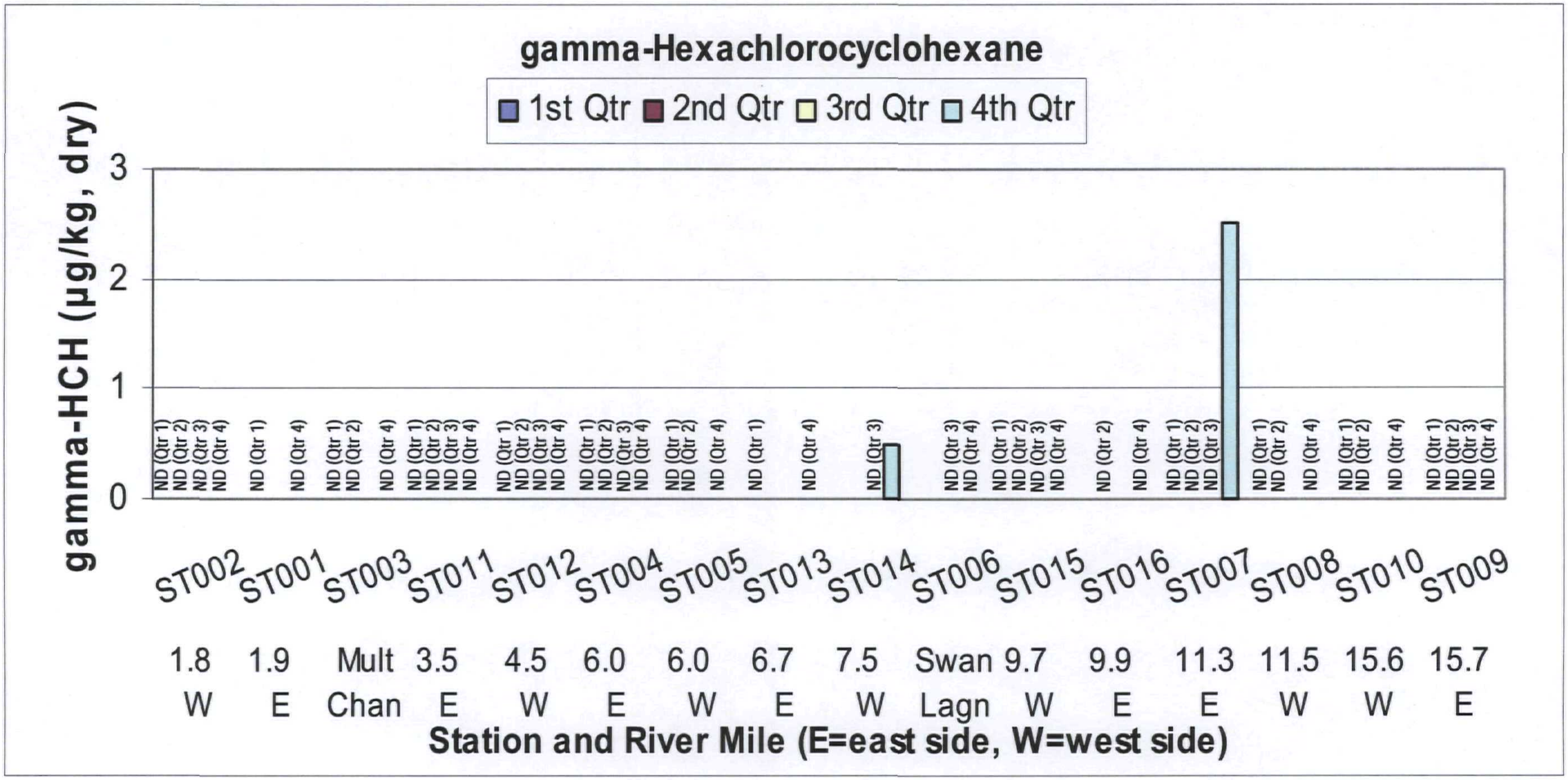
Figure D2.1-16
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Hexachlorobenzene
Concentrations for In-River Sediment Traps



Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.

ND=not detected at quarter shown

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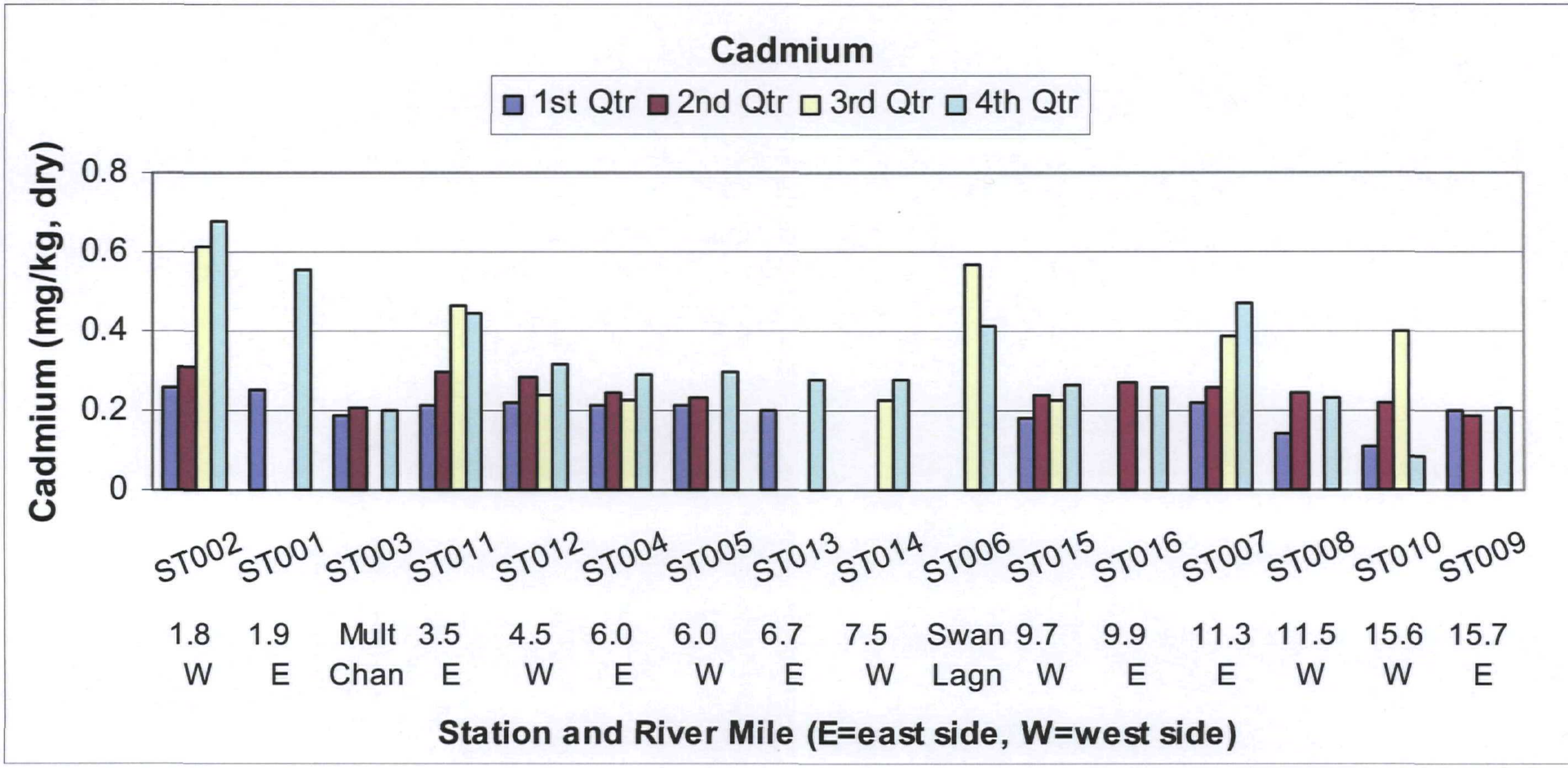
Figure D2.1-17
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of gamma-Hexachlorocyclohexane Concentrations for In-River Sediment Traps



Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.

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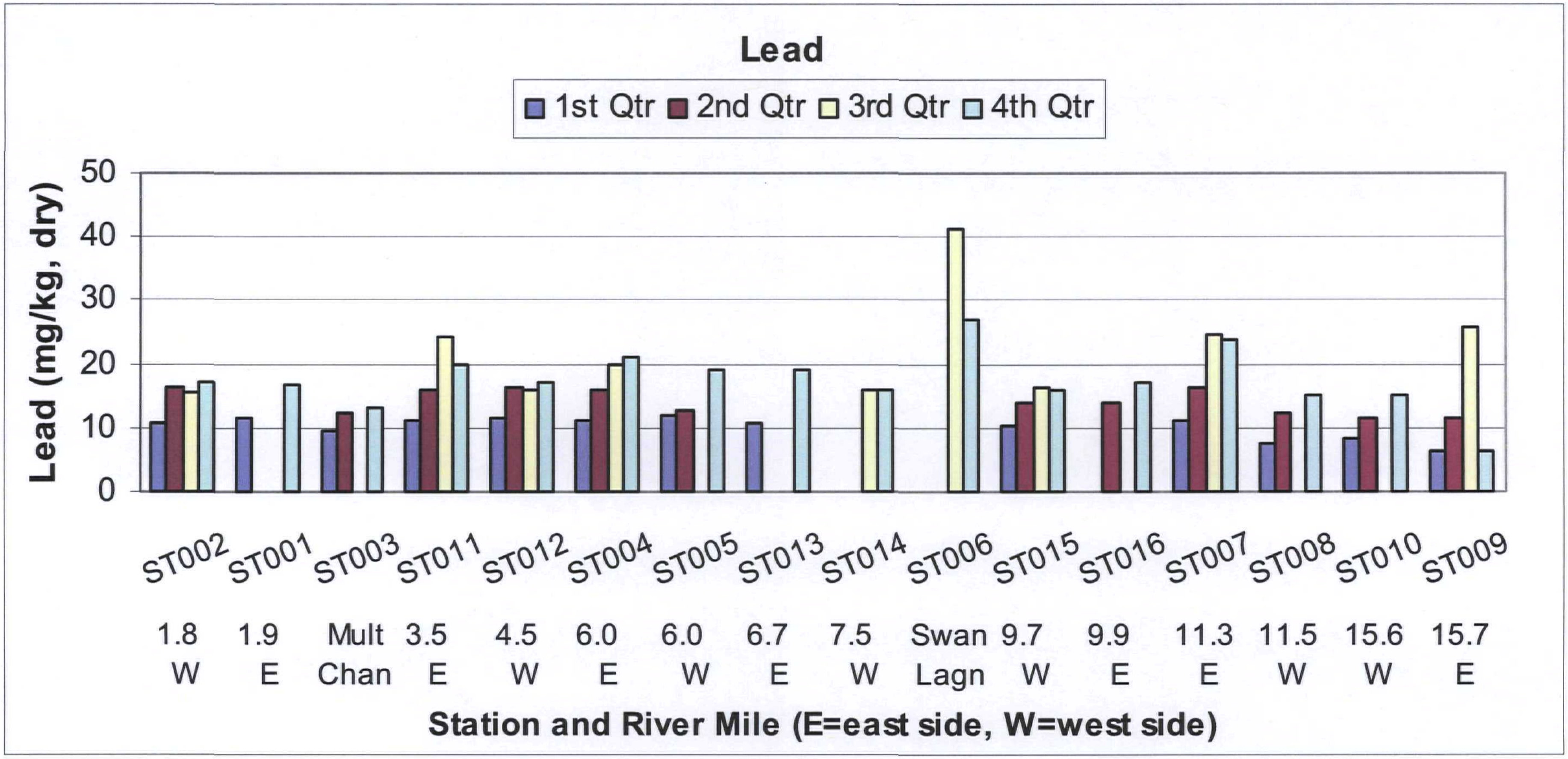
Figure D2.1-18
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Cadmium
Concentrations for In-River Sediment Traps



Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.

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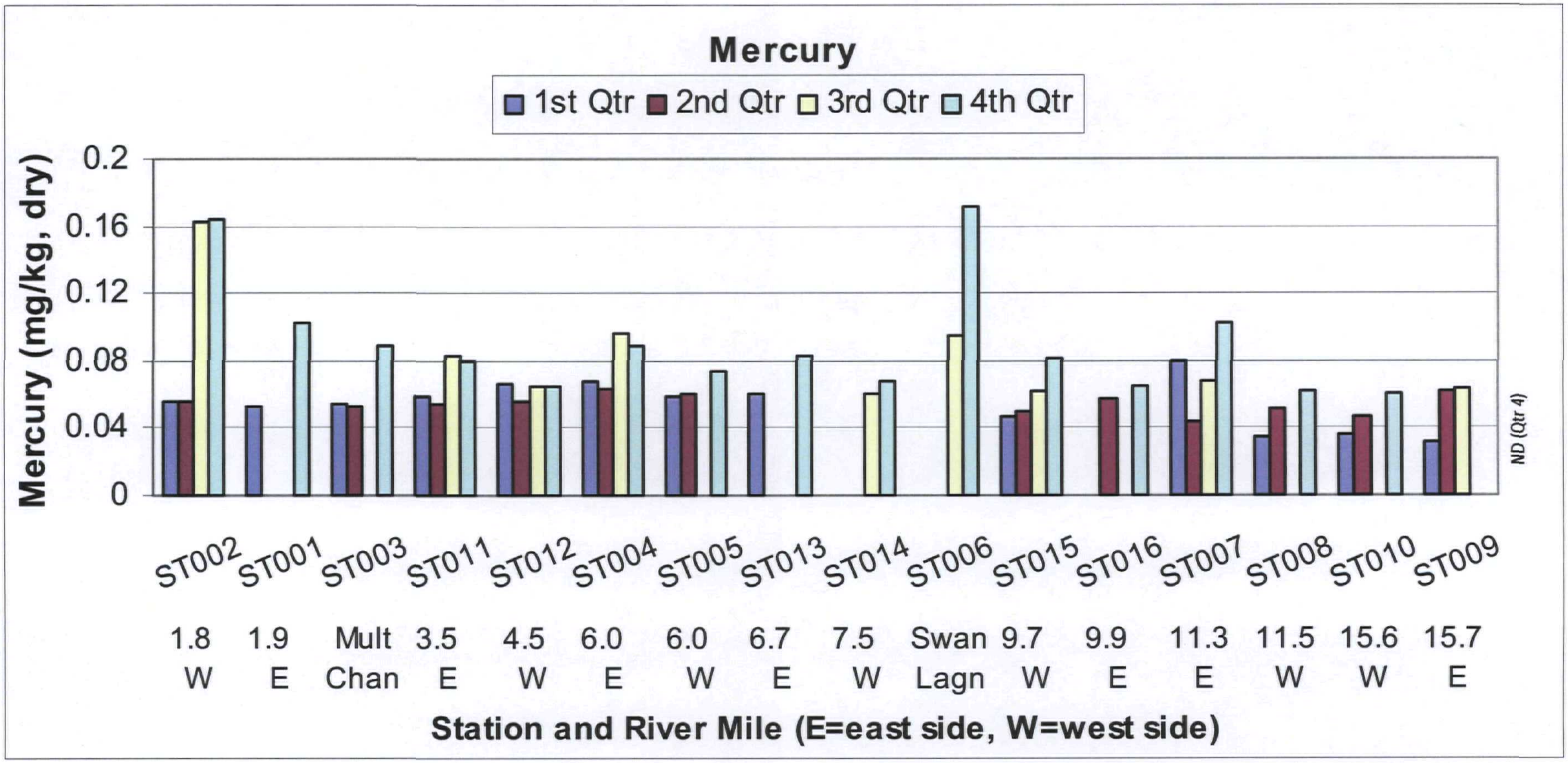
Figure D2.1-19
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Lead
Concentrations for In-River Sediment Traps



Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.
ND=not detected at quarter shown

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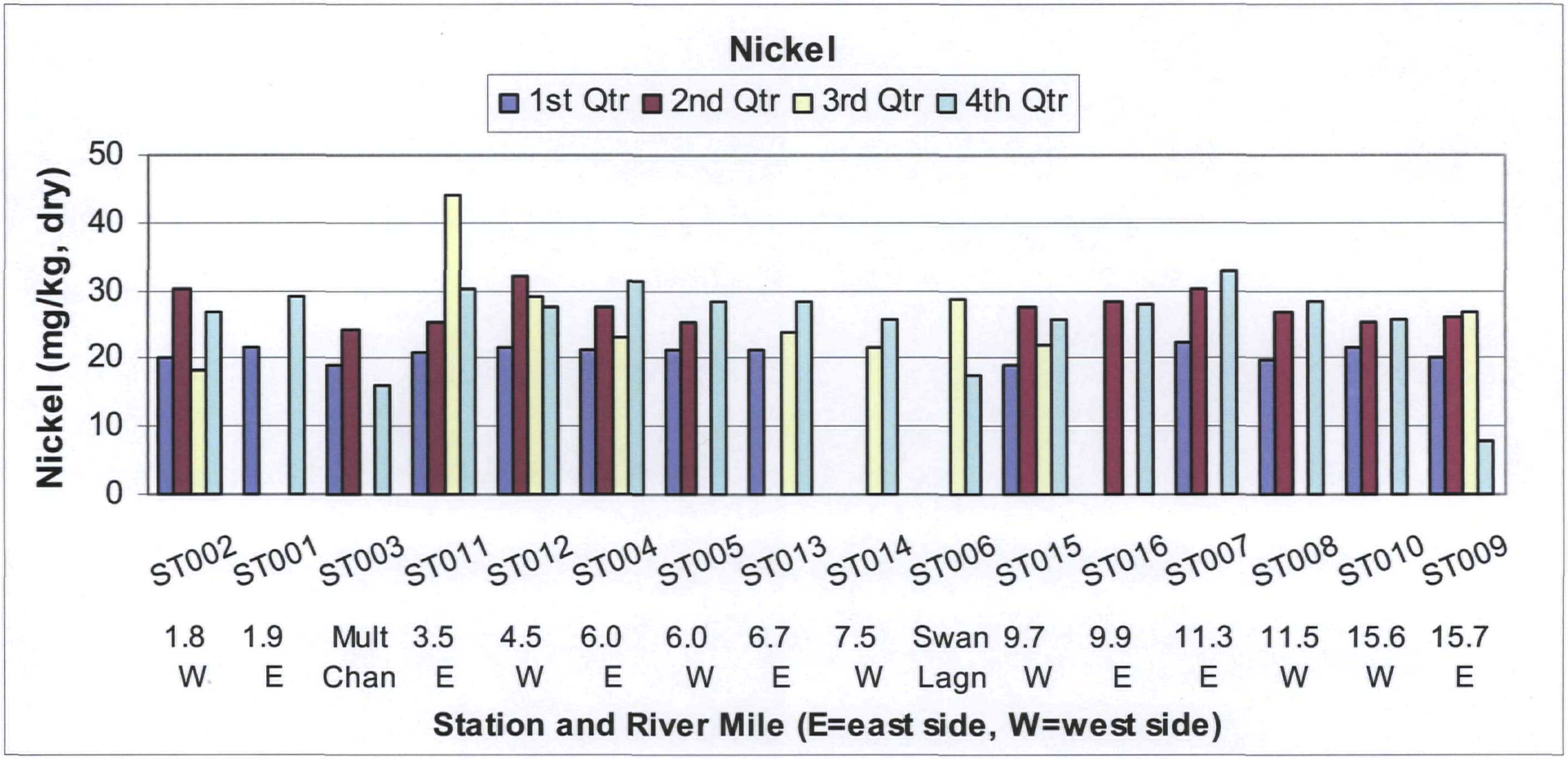
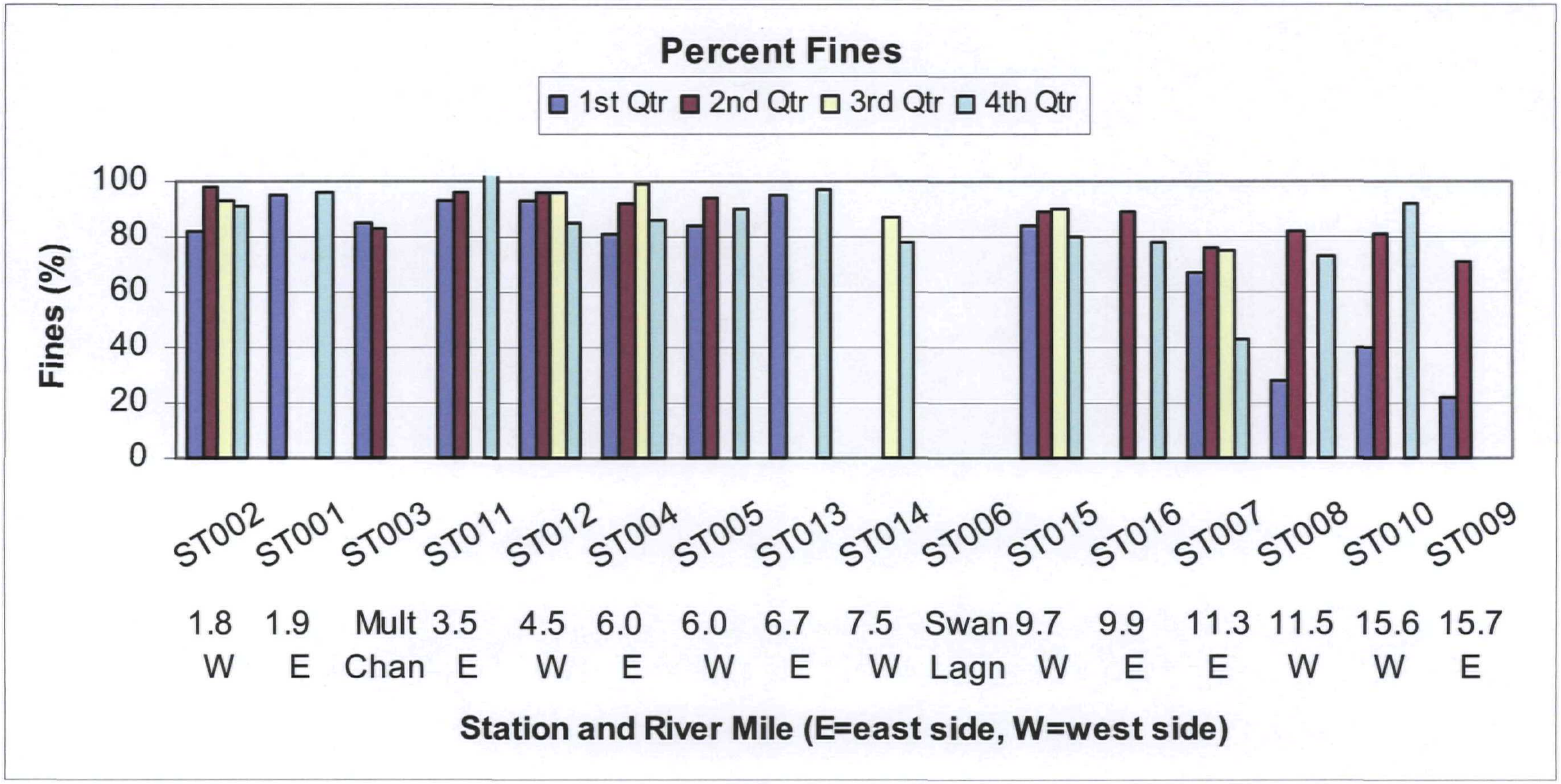
Figure D2.1-20
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Mercury
Concentrations for In-River Sediment Traps



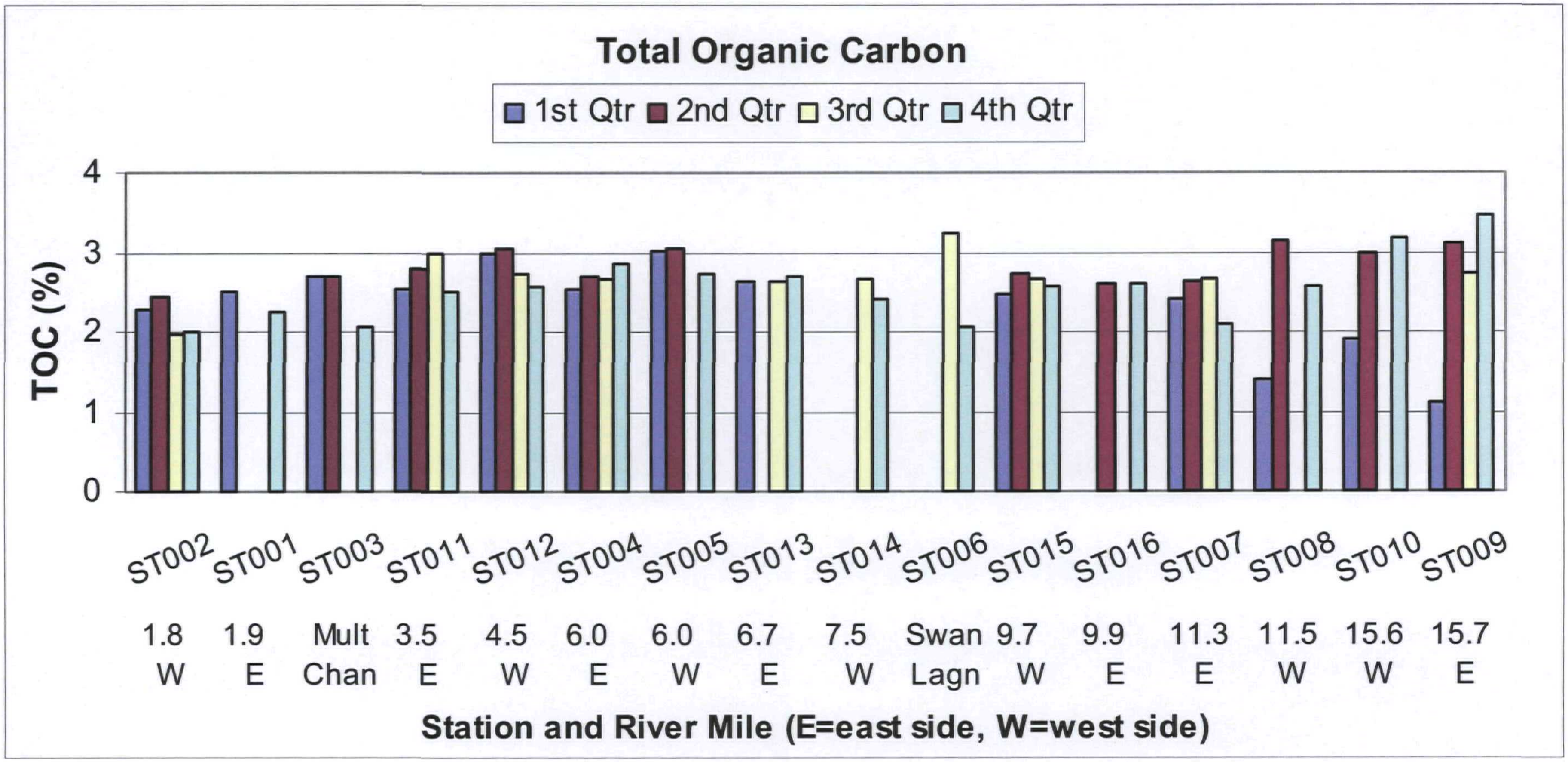
Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.

Figure D2.1-21
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Nickel
Concentrations for In-River Sediment Traps



Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.

Figure D2.1-22
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Percent Fines
for In-River Sediment Traps



Note: Blank spaces within station groupings indicate that traps were lost or the quarterly volume of material collected was not sufficient for analysis.

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Figure D2.1-23
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total Organic Carbon
Concentrations for In-River Sediment Traps

Appendix D2.2

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PORTLAND HARBOR RI/FS

REMEDIAL INVESTIGATION REPORT

APPENDIX D2.2
SEDIMENT TRAP SUMMARY STATISTICS FOR ALL ANALYTES (ON CD)

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PORTLAND HARBOR RI/FS

REMEDIAL INVESTIGATION REPORT

APPENDIX D3
SURFACE WATER

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Appendix D3.1

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PORTLAND HARBOR RI/FS
REMEDIAL INVESTIGATION REPORT

APPENDIX D3.1
SURFACE WATER HISTOGRAMS
(FOR ICS NOT PRESENTED IN MAIN REPORT)

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October 27, 2009

LIST OF FIGURES

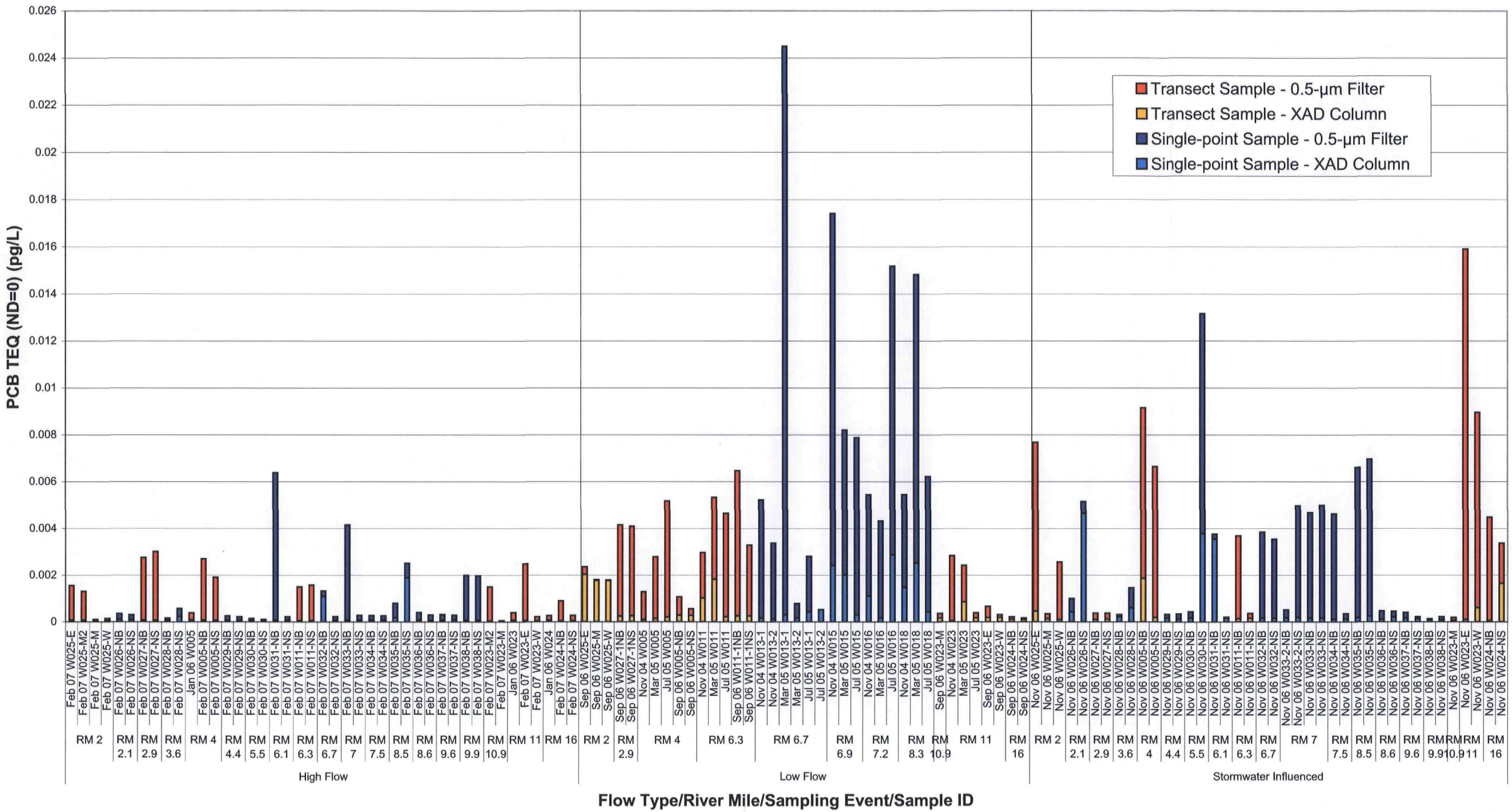

Figure D3.1-1
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of PCB TEQ (ND=0) Concentrations
in Surface Water, RM 2-16 (XAD)

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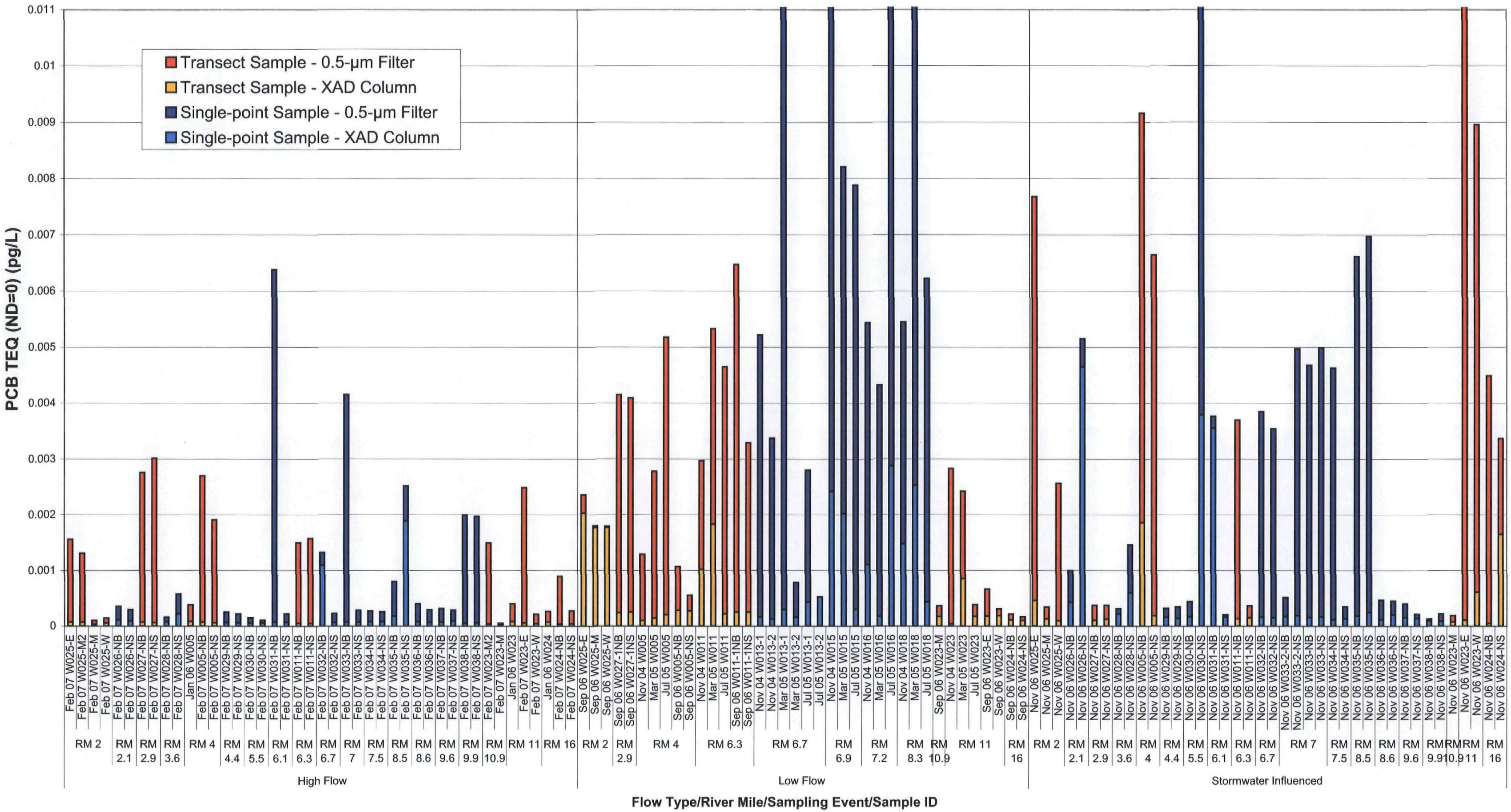

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Figure D3.1-2
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of PCB TEQ (ND=0) Concentrations in Surface Water, RM 2-16 (XAD) (scale zoomed)

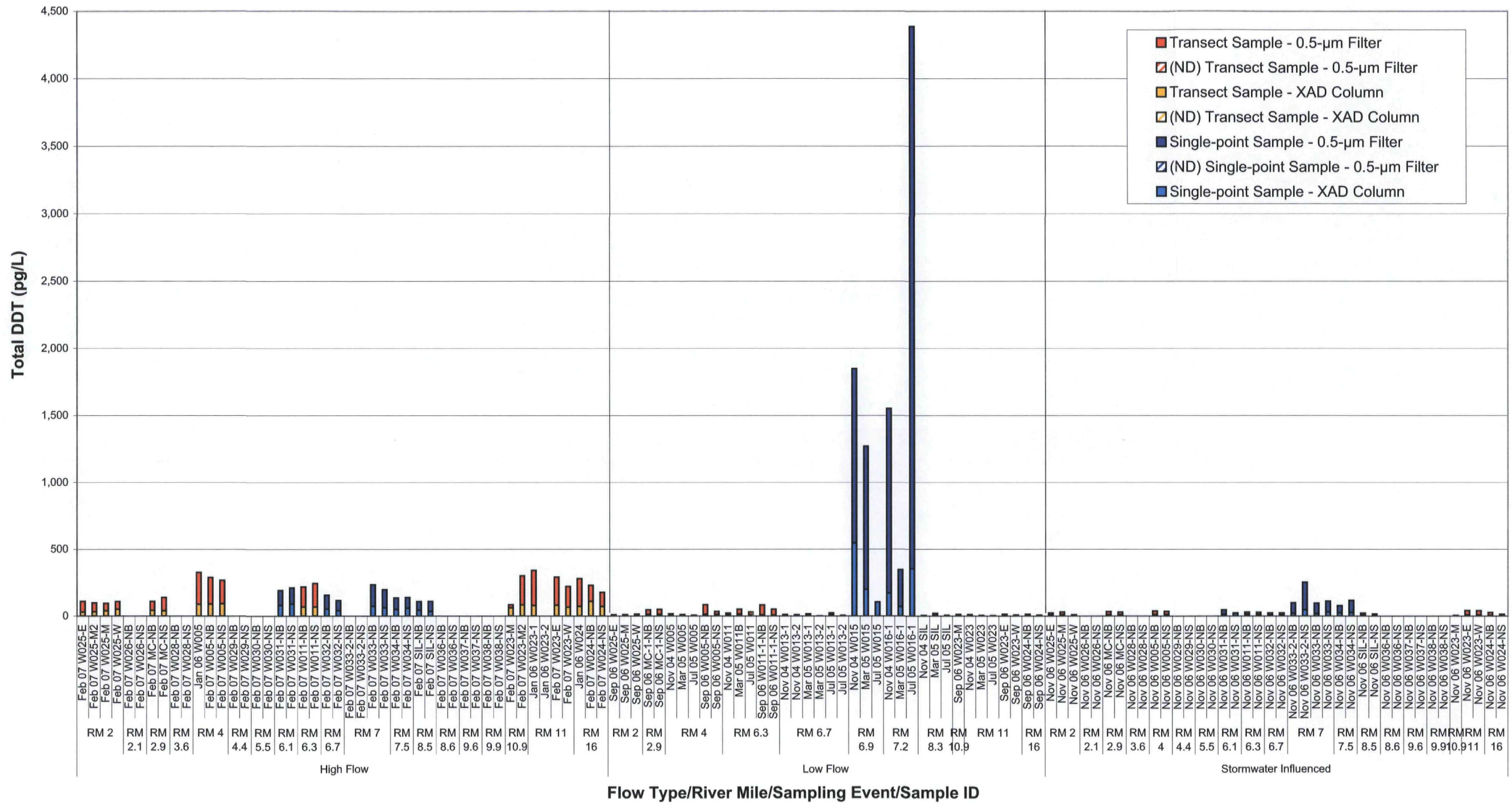

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Figure D3.1-3
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total of 2,4'- and 4,4'-DDT Concentrations in Surface Water, RM 2-16 (XAD)

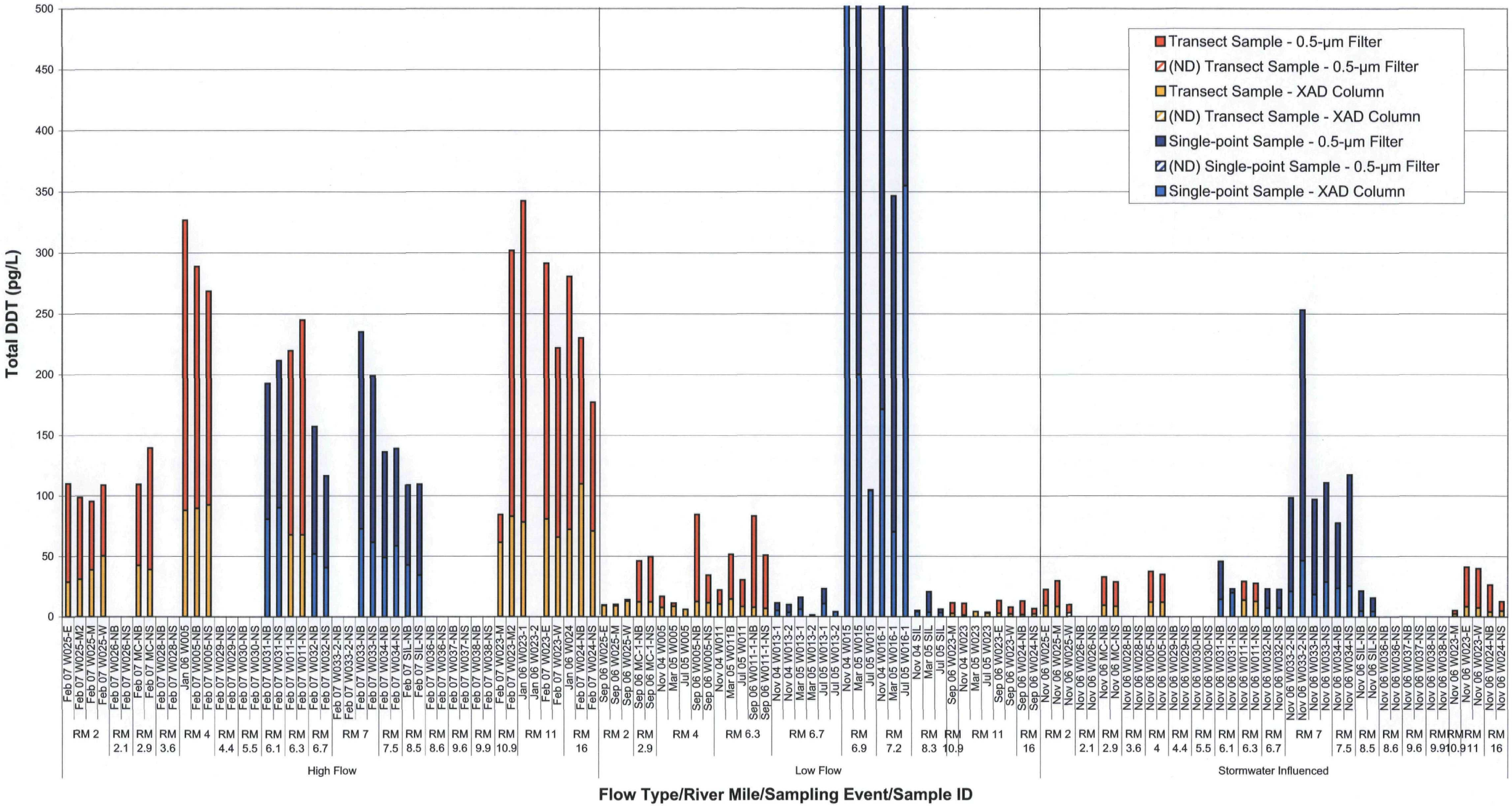

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Figure D3.1-4
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total of 2,4'- and 4,4'-DDT Concentrations in Surface Water, RM 2-16 (XAD) (scale zoomed)

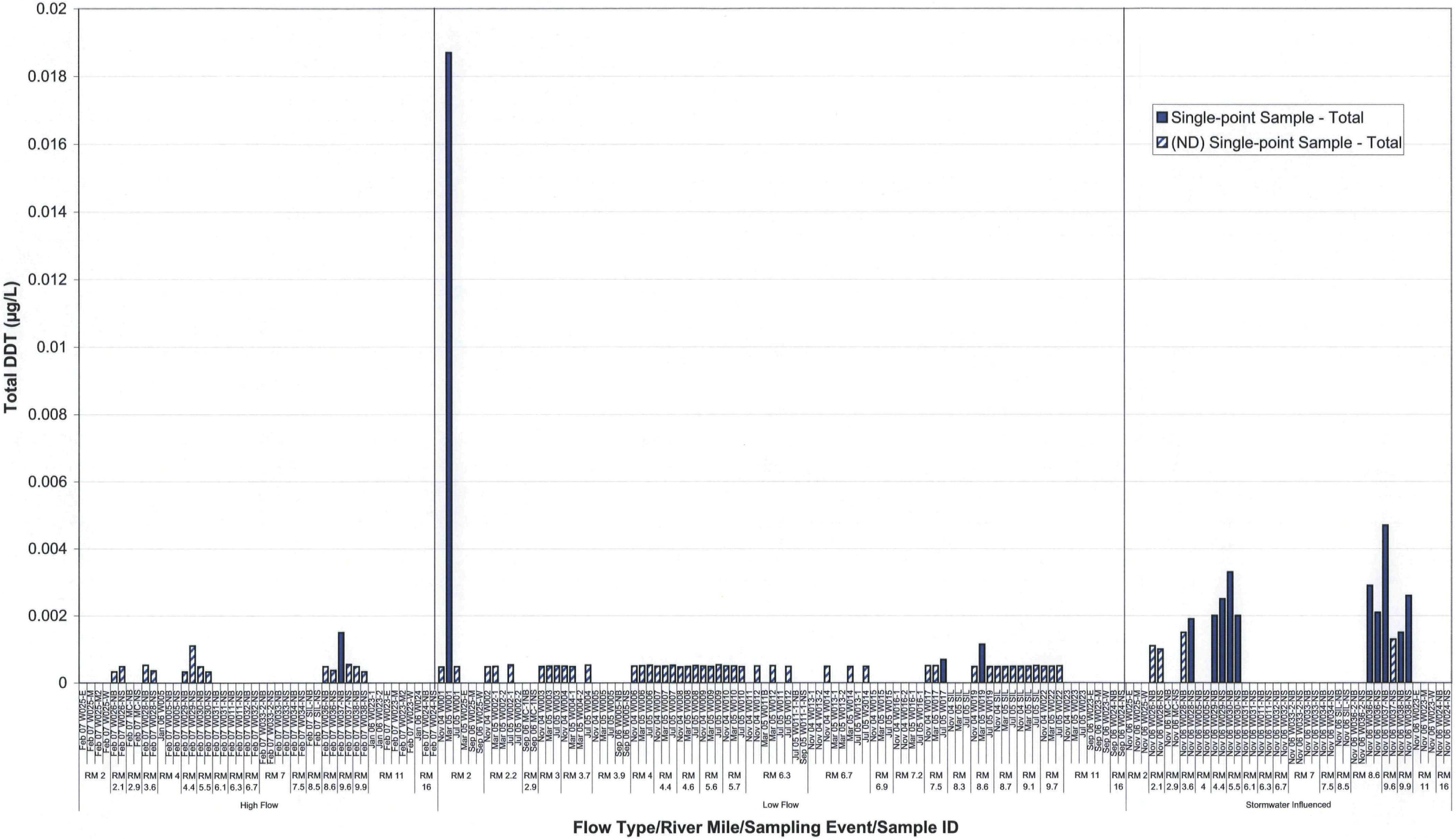

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Figure D3.1-5
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total of 2,4'- and 4,4'-DDT Concentrations in Surface Water, RM 2-16 (Peristaltic)

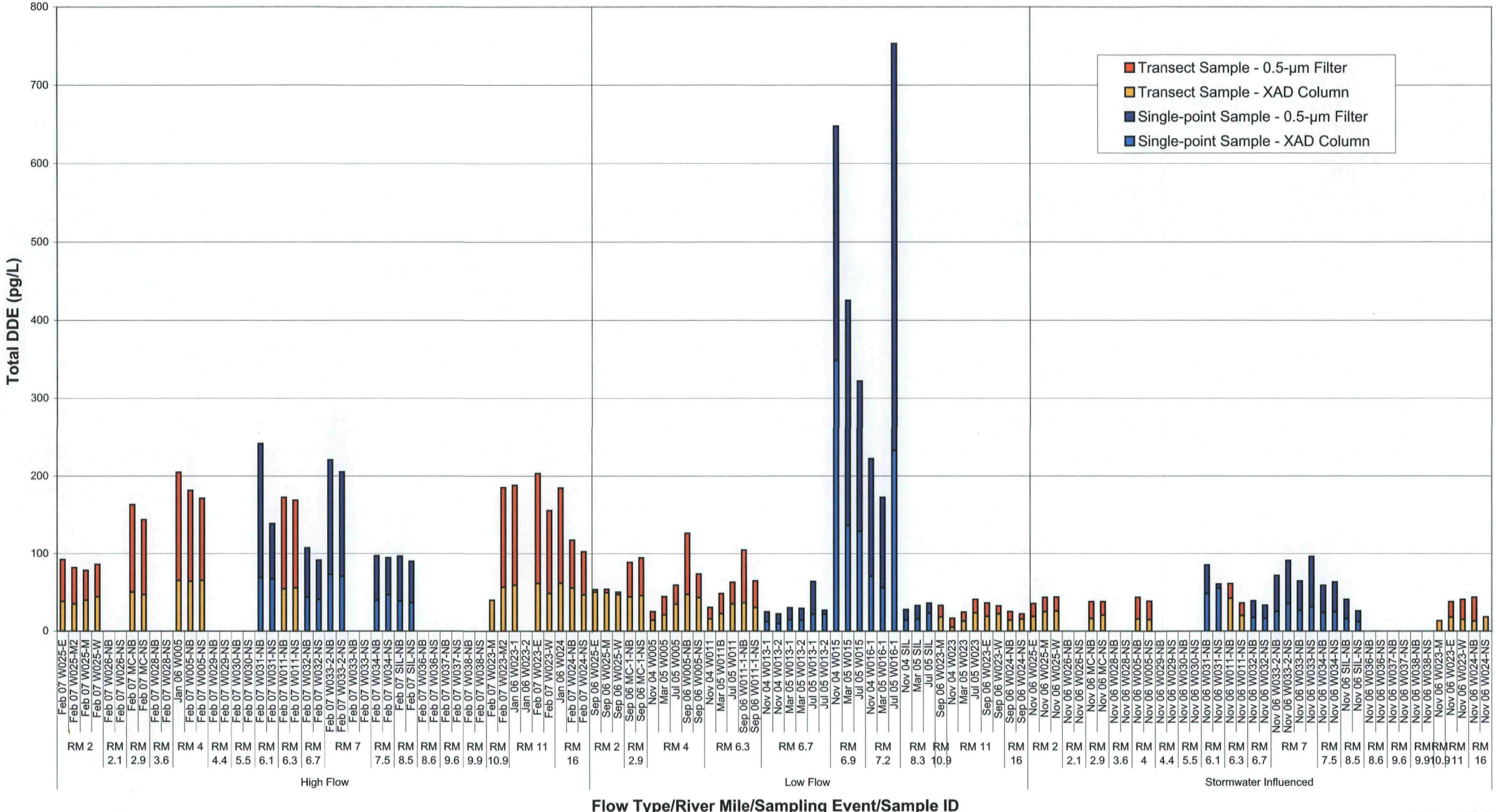

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Figure D3.1-6

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Draft Remedial Investigation Report

Histogram of Total of 2,4'- and 4,4'-DDE Concentrations in Surface Water, RM 2-16 (XAD)

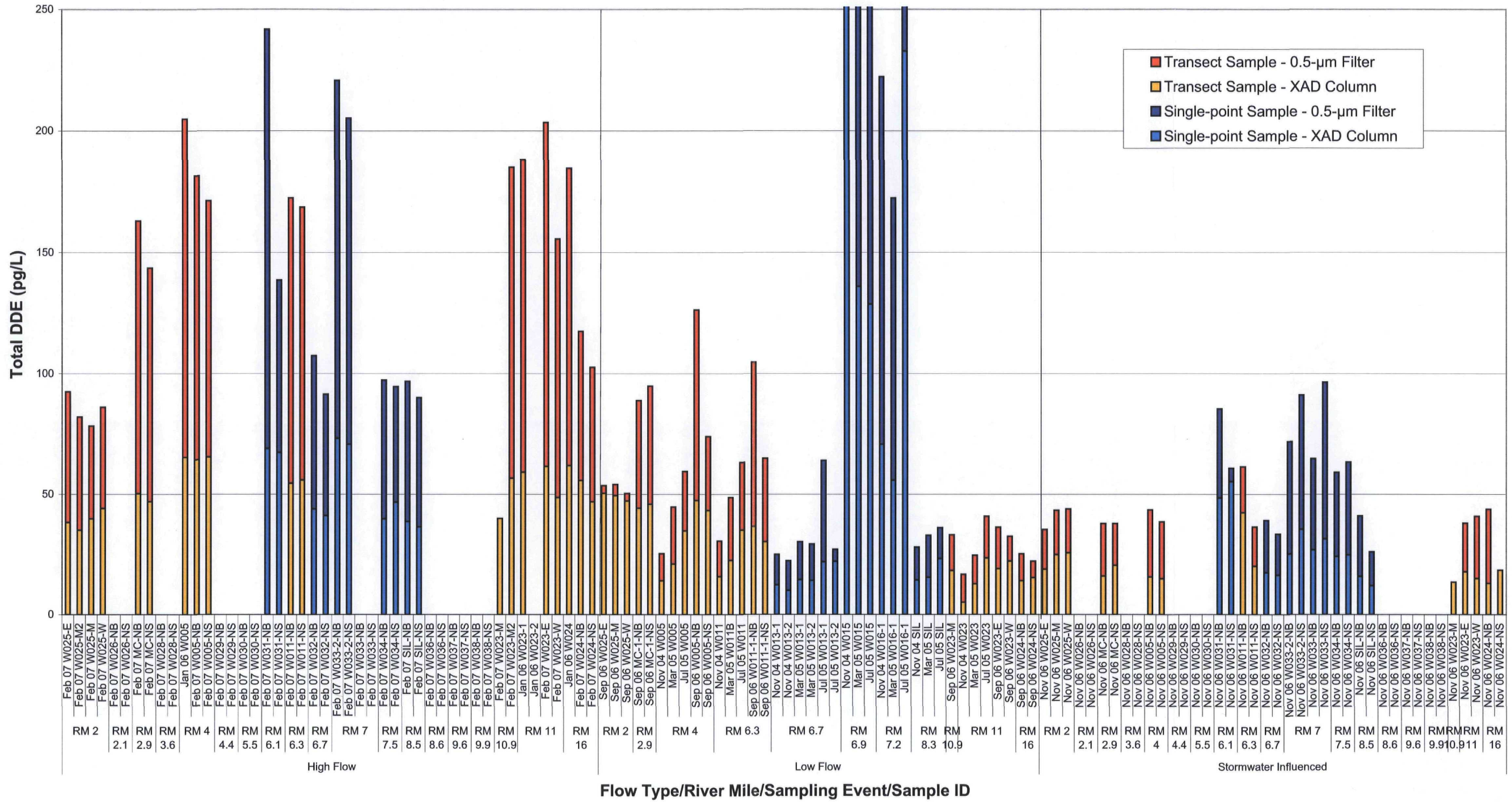

Figure D3.1-7
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total of 2,4'- and 4,4'-DDE Concentrations in Surface Water, RM 2-16 (XAD) (scale zoomed)

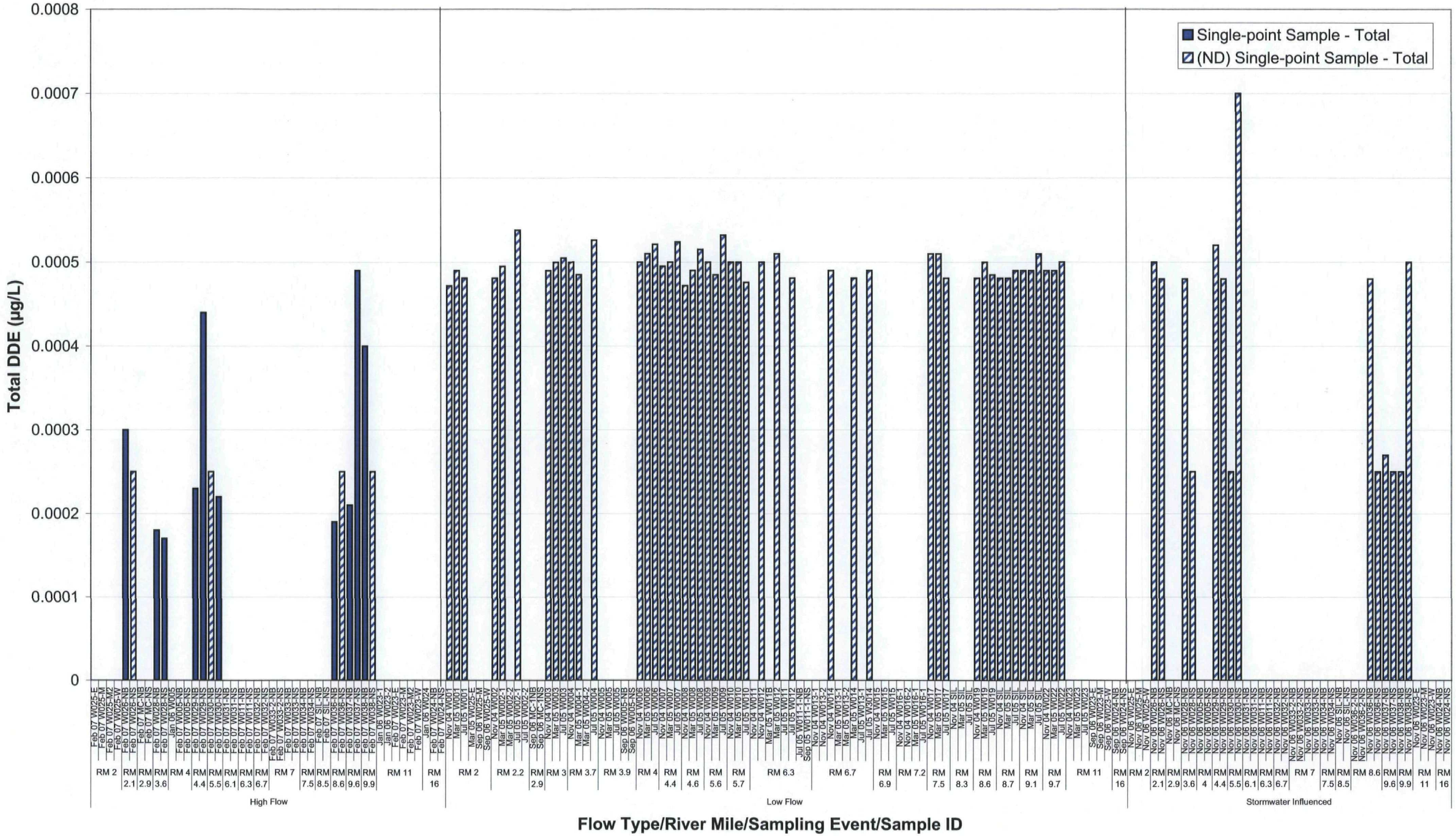

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Figure D3.1-8
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total of 2,4'- and 4,4'-DDE Concentrations in Surface Water, RM 2-16 (Peristaltic)

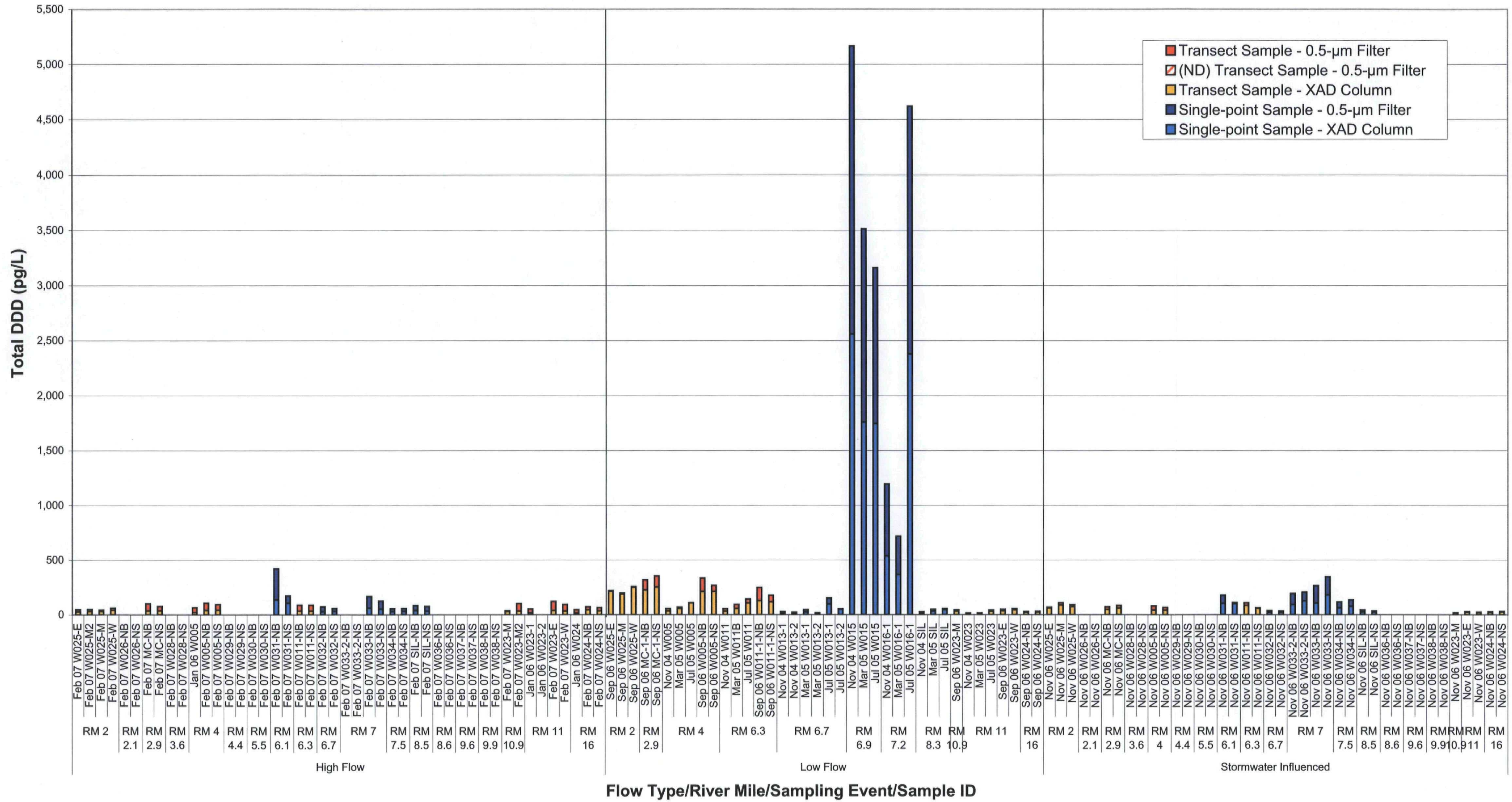

Figure D3.1-9
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total of 2,4'- and 4,4'-DDD Concentrations in Surface Water, RM 2-16 (XAD)

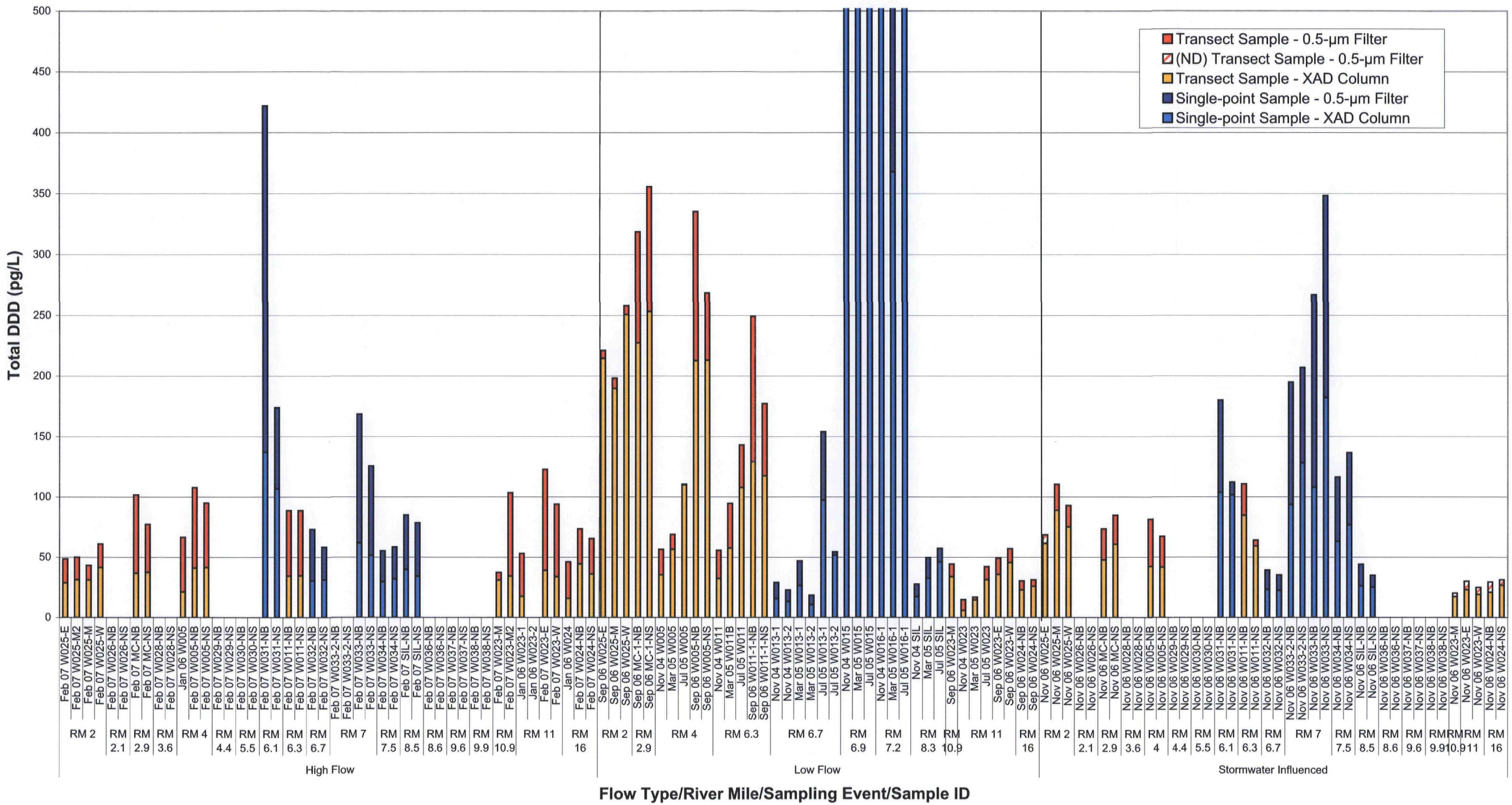

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Figure D3.1-10
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total of 2,4'- and 4,4'-DDD Concentrations in Surface Water, RM 2-16 (XAD) (scale zoomed)

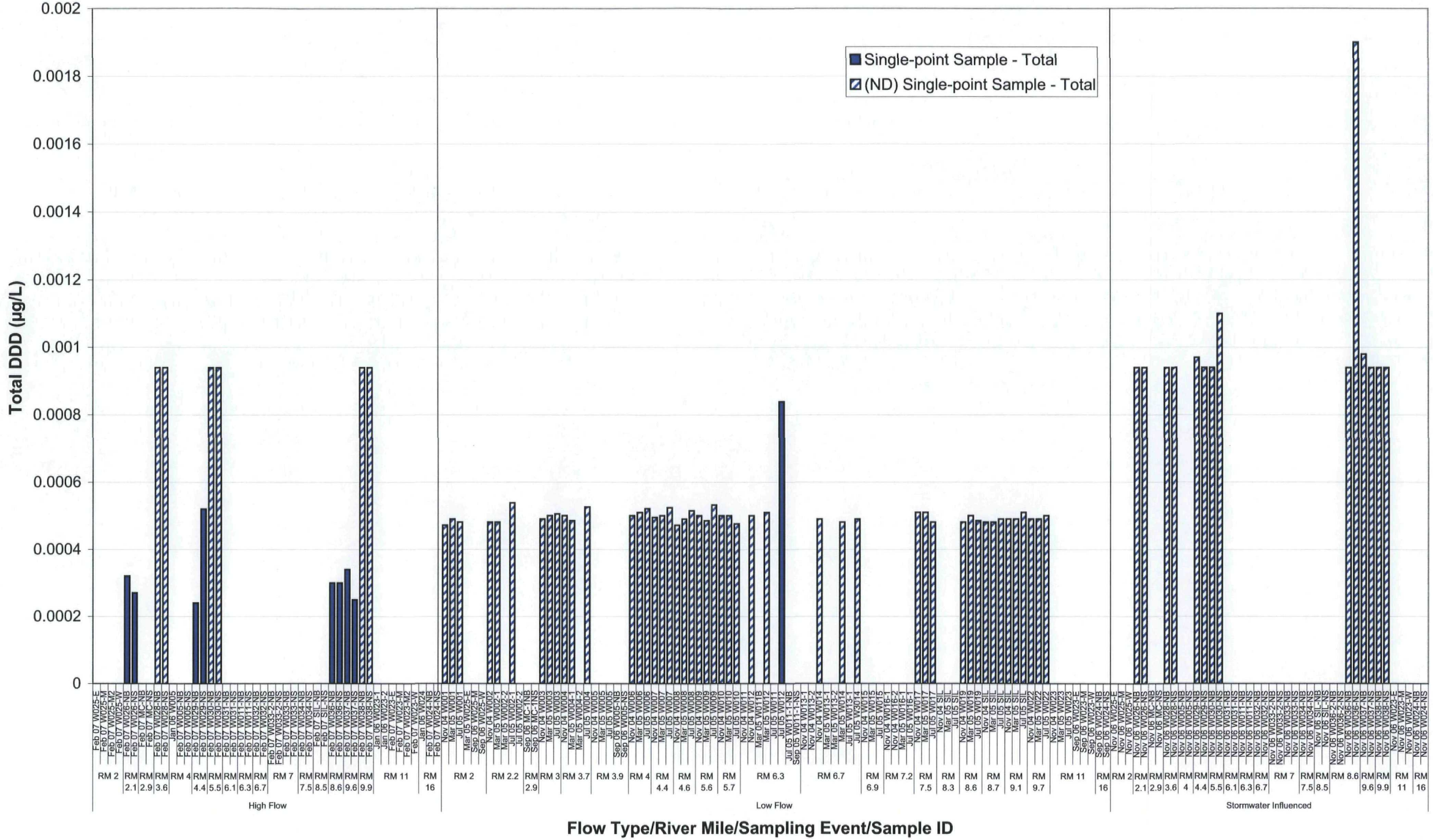

Figure D3.1-11
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total of 2,4'- and 4,4'-DDD Concentrations in Surface Water, RM 2-16 (Peristaltic)

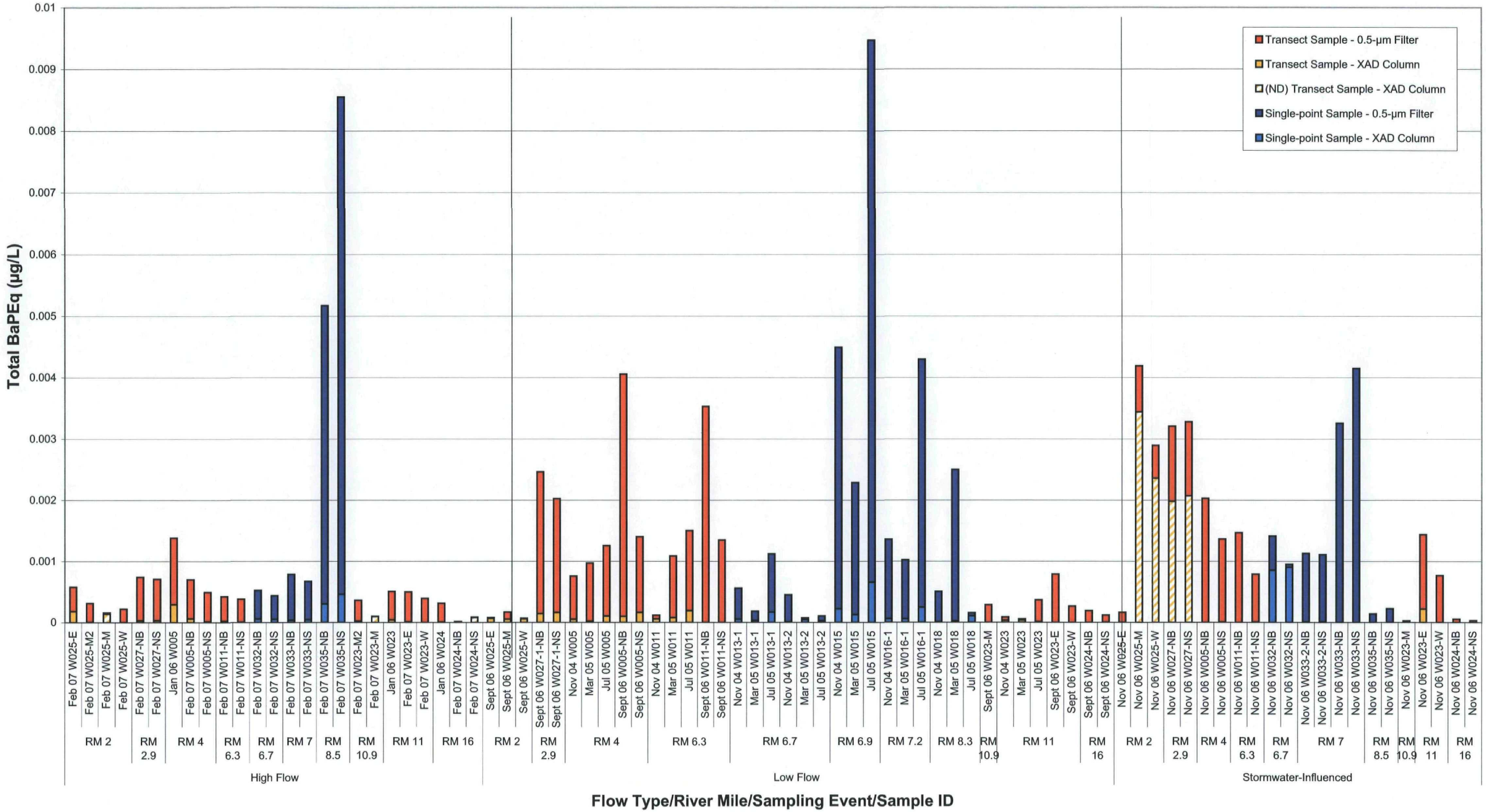

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Figure D3.1-12
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total cPAH BaPEq Value Concentrations in Surface Water, RM 2-16 (XAD)

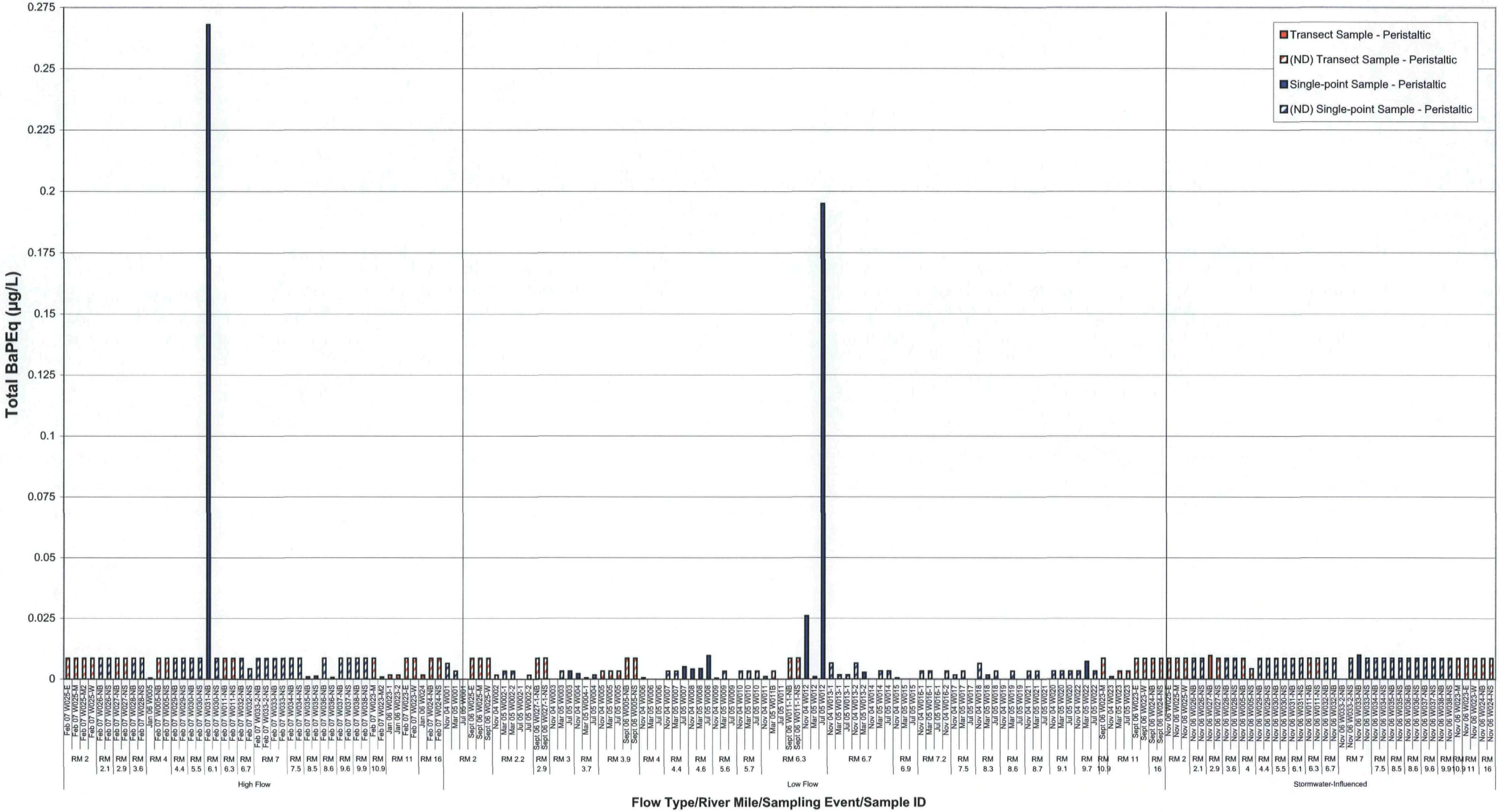

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Figure D3.1-13
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total cPAH BaPEq Value Concentrations in Surface Water, RM 2-16 (Peristaltic)

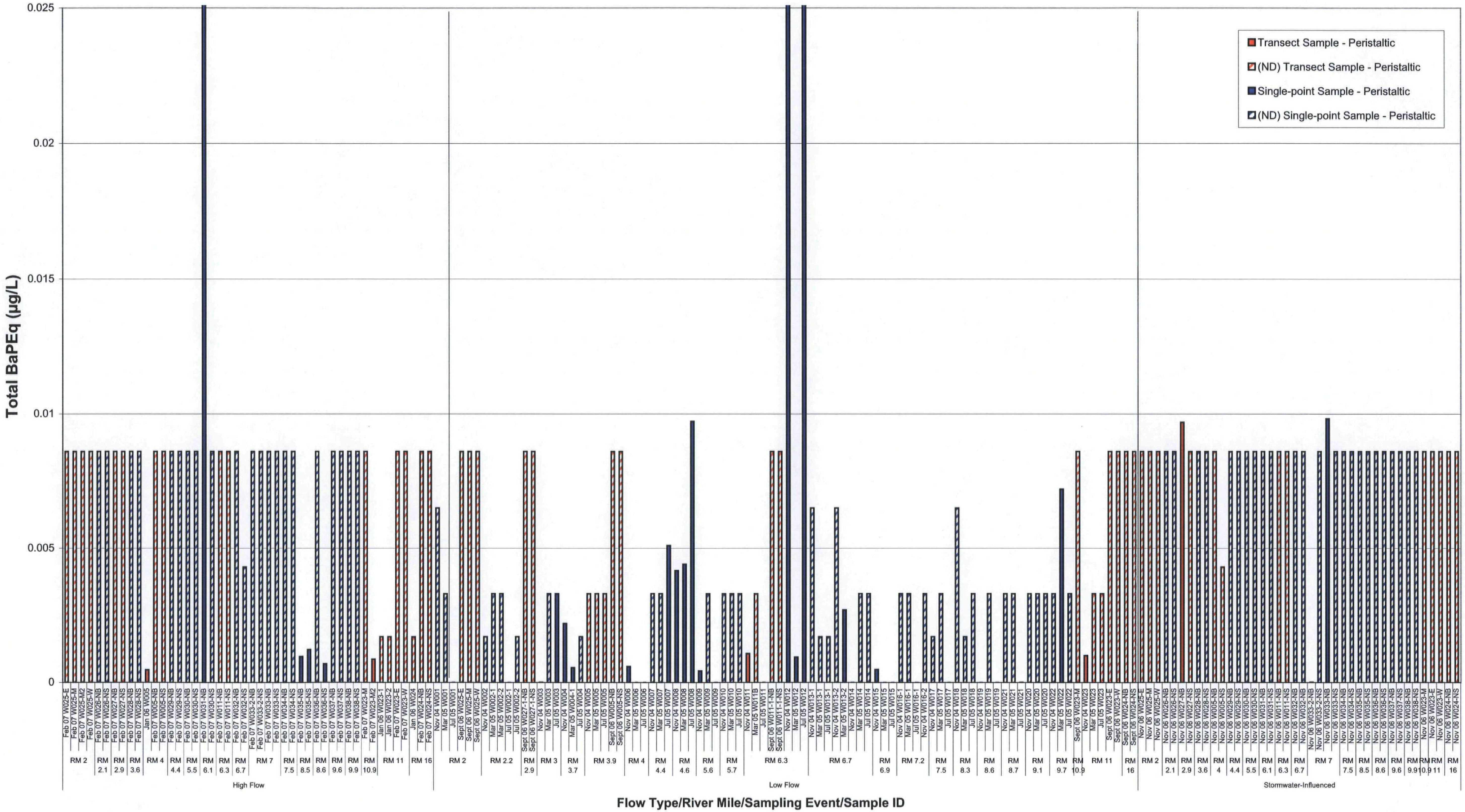

Figure D3.1-14
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total cPAH BaPEq Value Concentrations
in Surface Water, RM 2-16 (Peristaltic) (scale zoomed)

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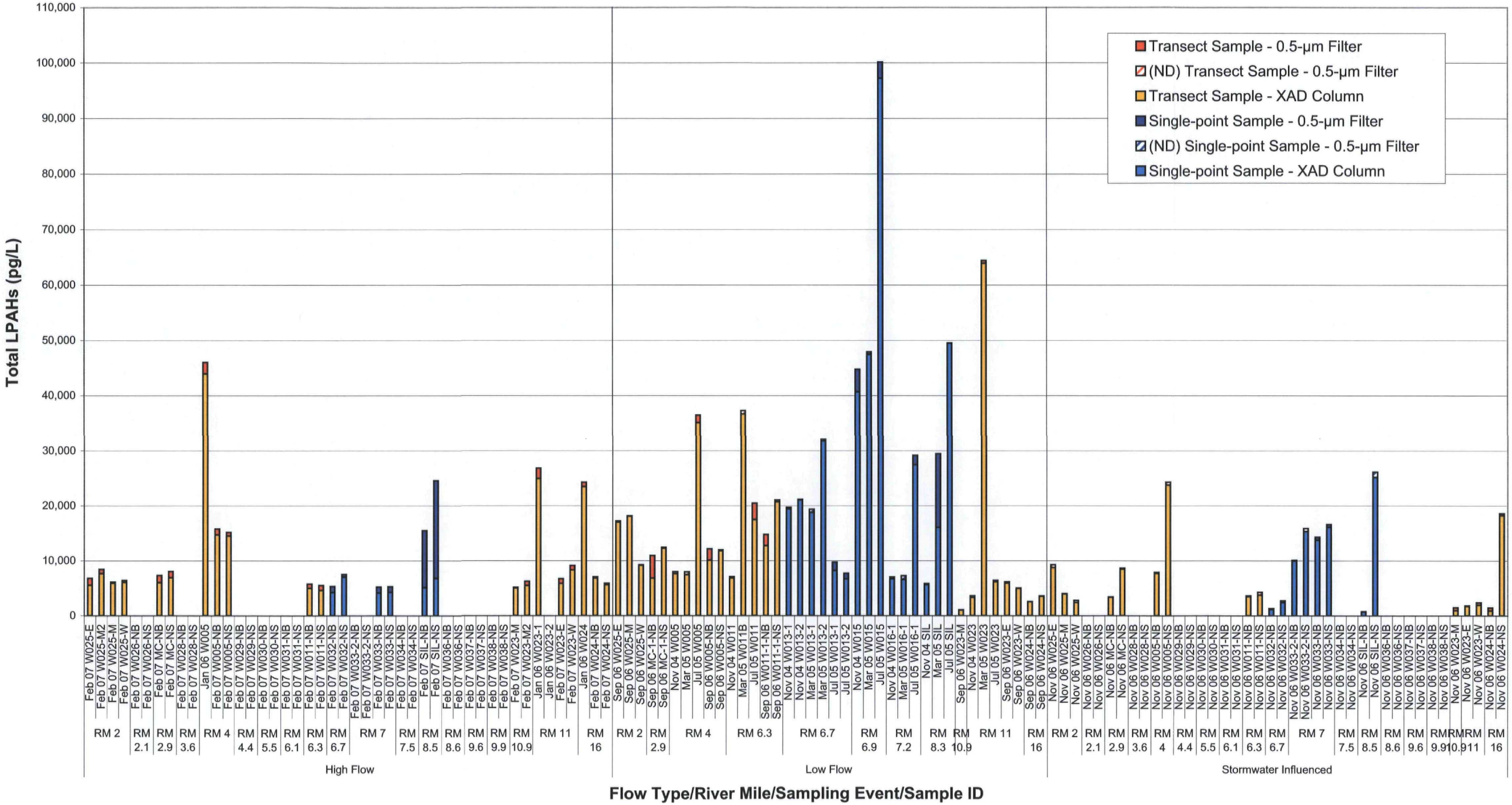

Figure D3.1-15
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total Low Molecular Weight PAH Concentrations in Surface Water, RM 2-16 (XAD)

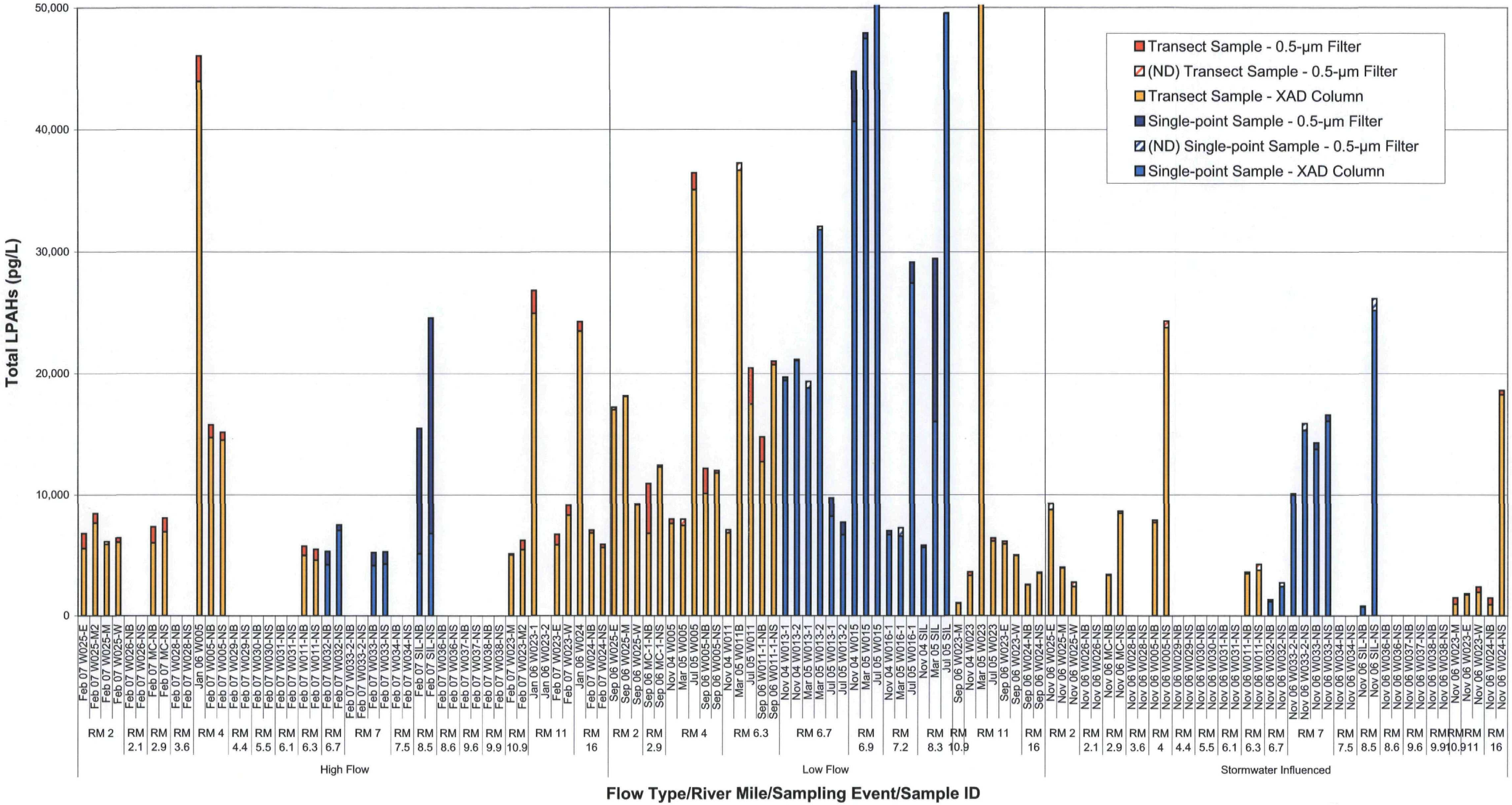

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Figure D3.1-16
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total Low Molecular Weight PAH Concentrations in Surface Water, RM 2-16 (XAD) (scale zoomed)

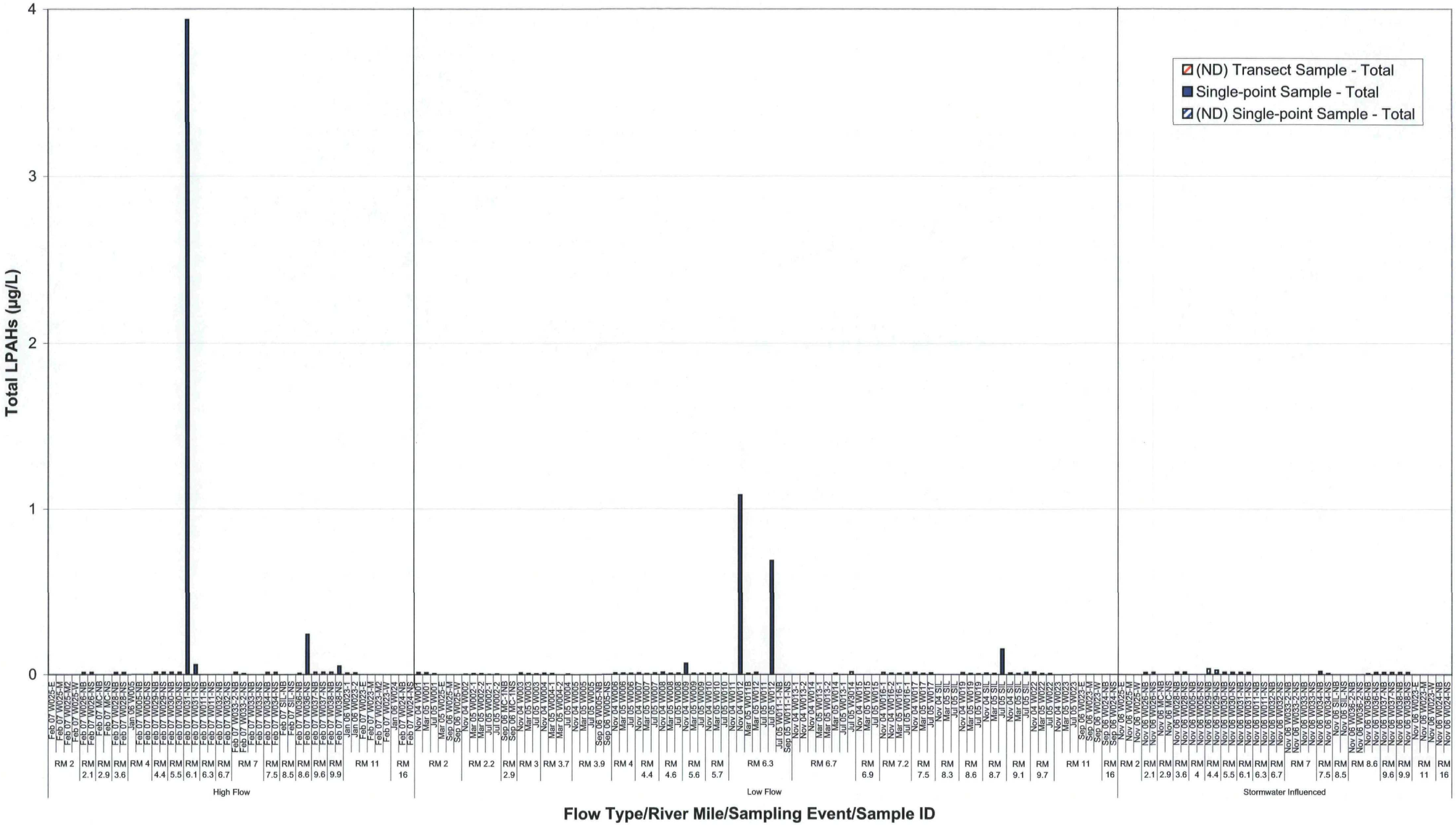

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Figure D3.1-17

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Draft Remedial Investigation Report

Histogram of Total Low Molecular Weight PAH Concentrations in Surface Water, RM 2-16 (Peristaltic)

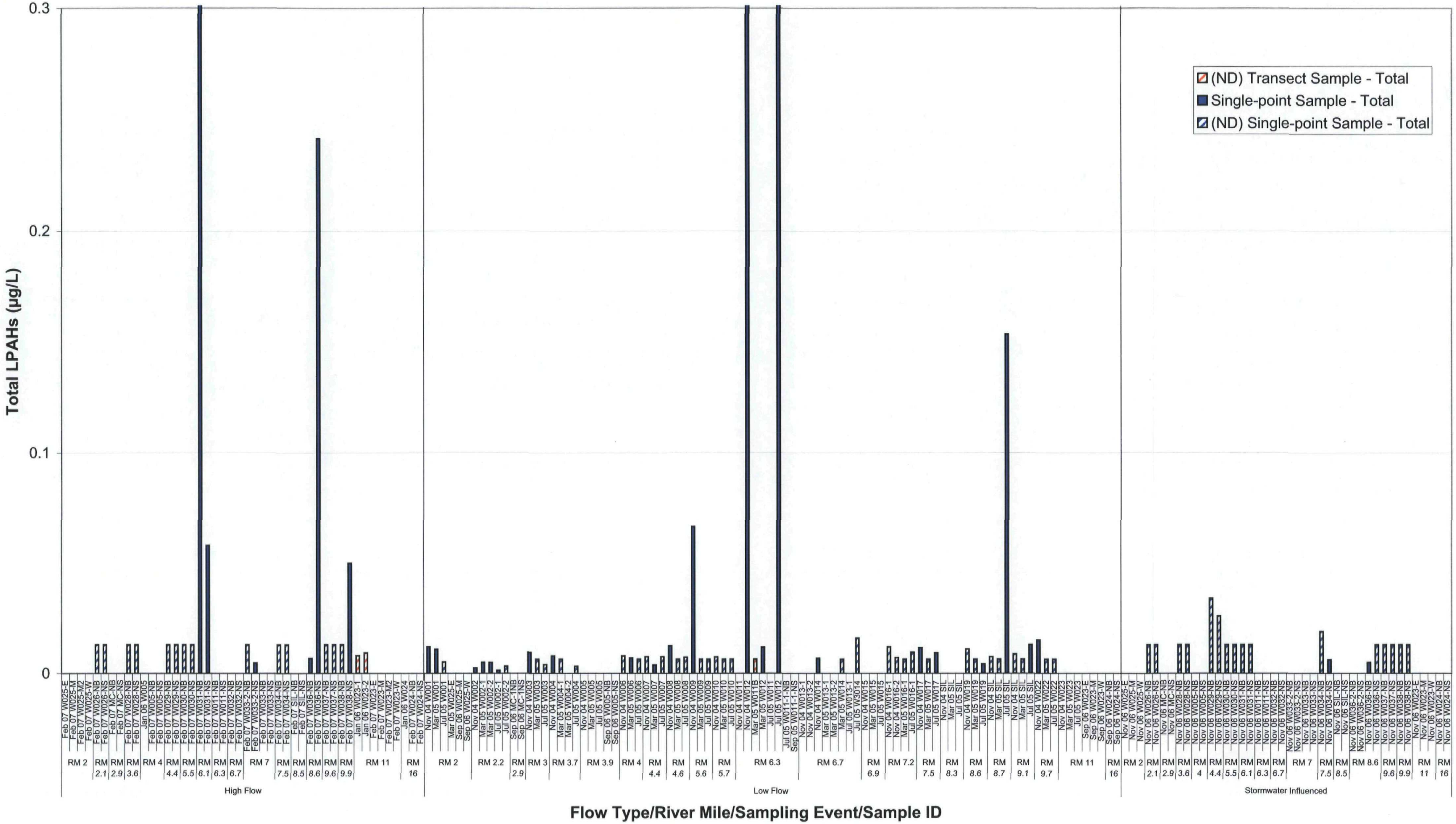

Figure D3.1-18
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total Low Molecular Weight PAH Concentrations in Surface Water, RM 2-16 (Peristaltic) (scale zoomed)

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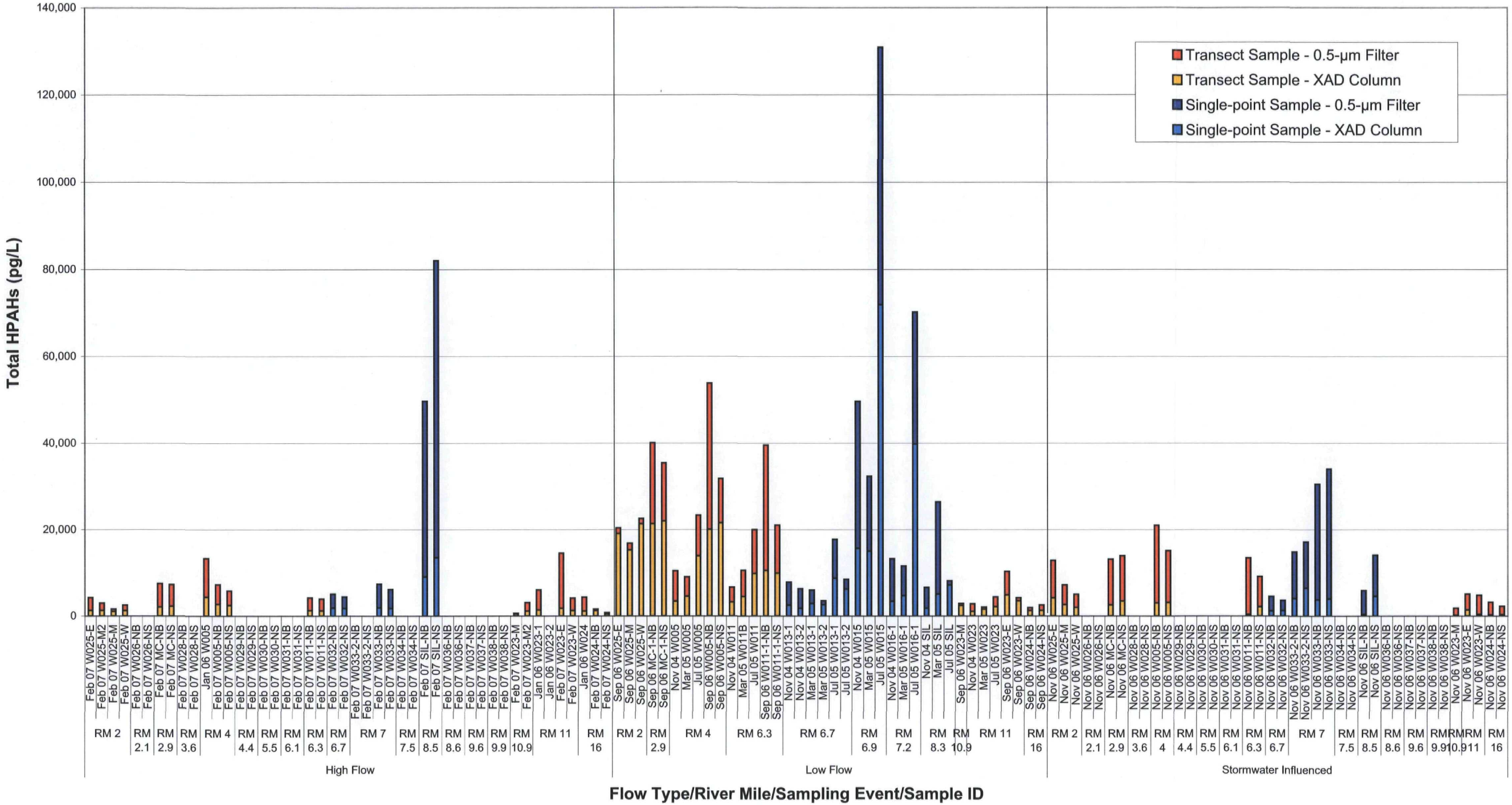

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Figure D3.1-19
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total High Molecular Weight PAH Concentrations in Surface Water, RM 2-16 (XAD)

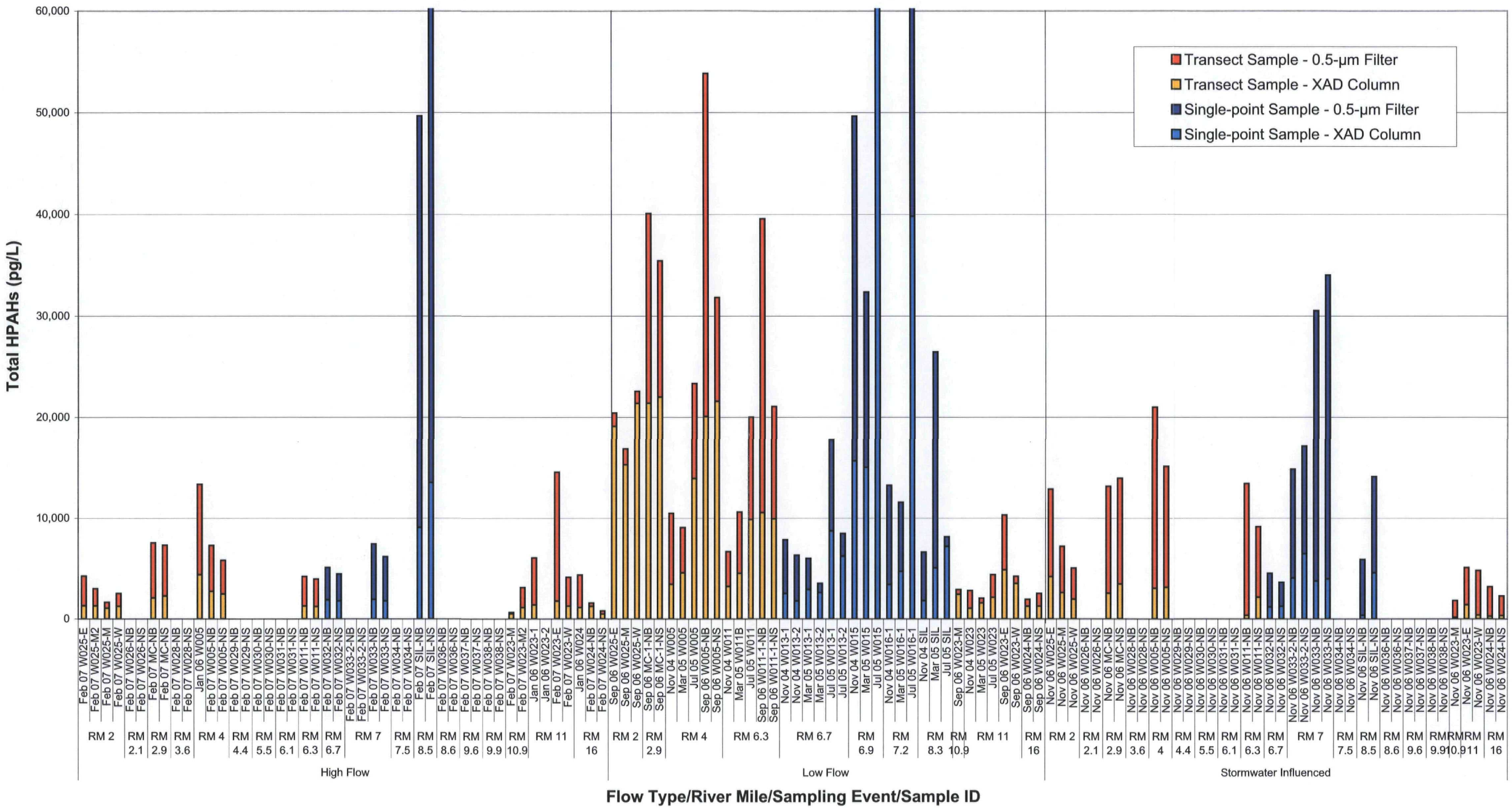

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Figure D3.1-20
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total High Molecular Weight PAH Concentrations in Surface Water, RM 2-16 (XAD) (scale zoomed)

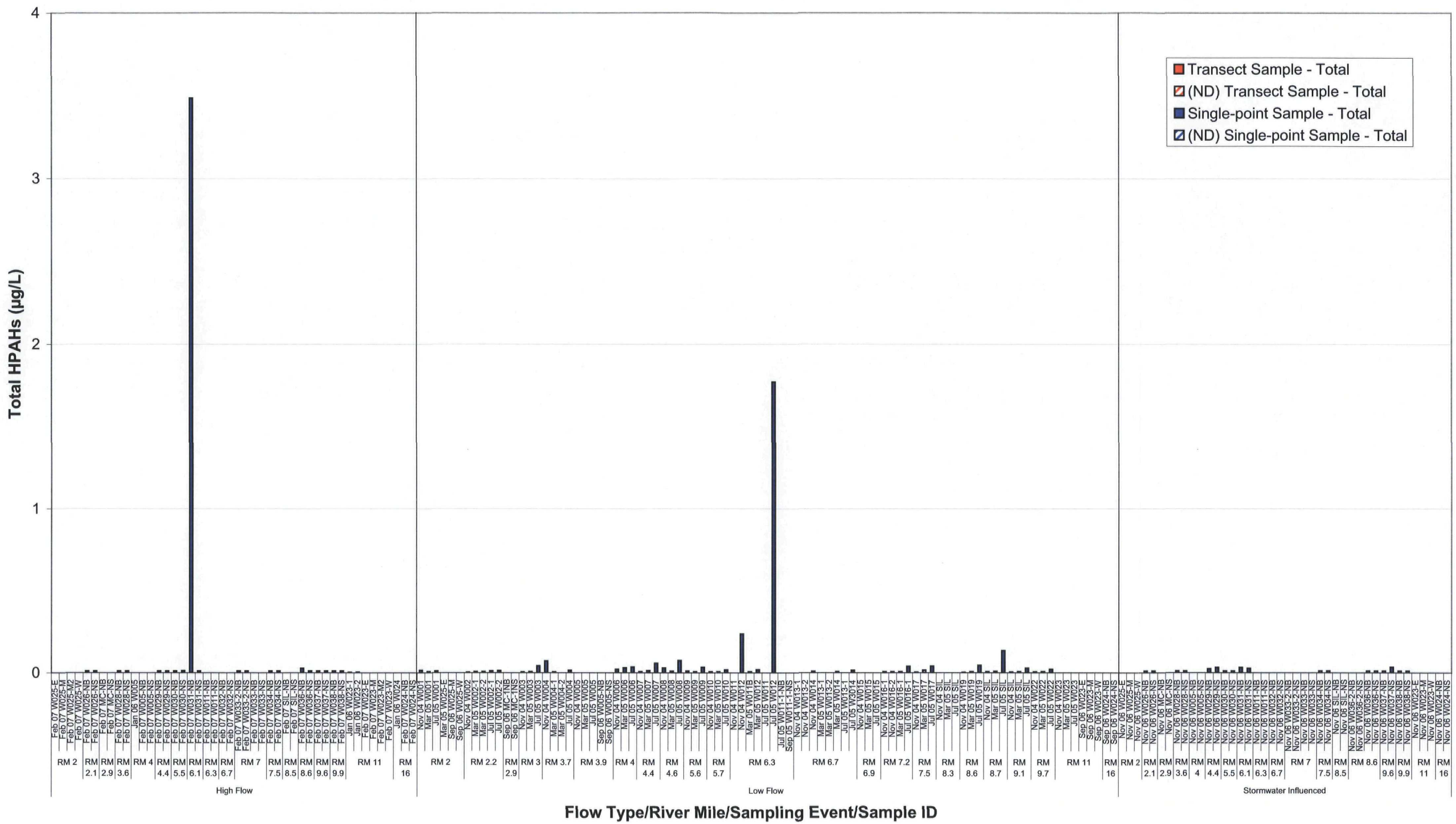

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Figure D3.1-21
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total High Molecular Weight PAH Concentrations in Surface Water, RM 2-16 (Peristaltic)

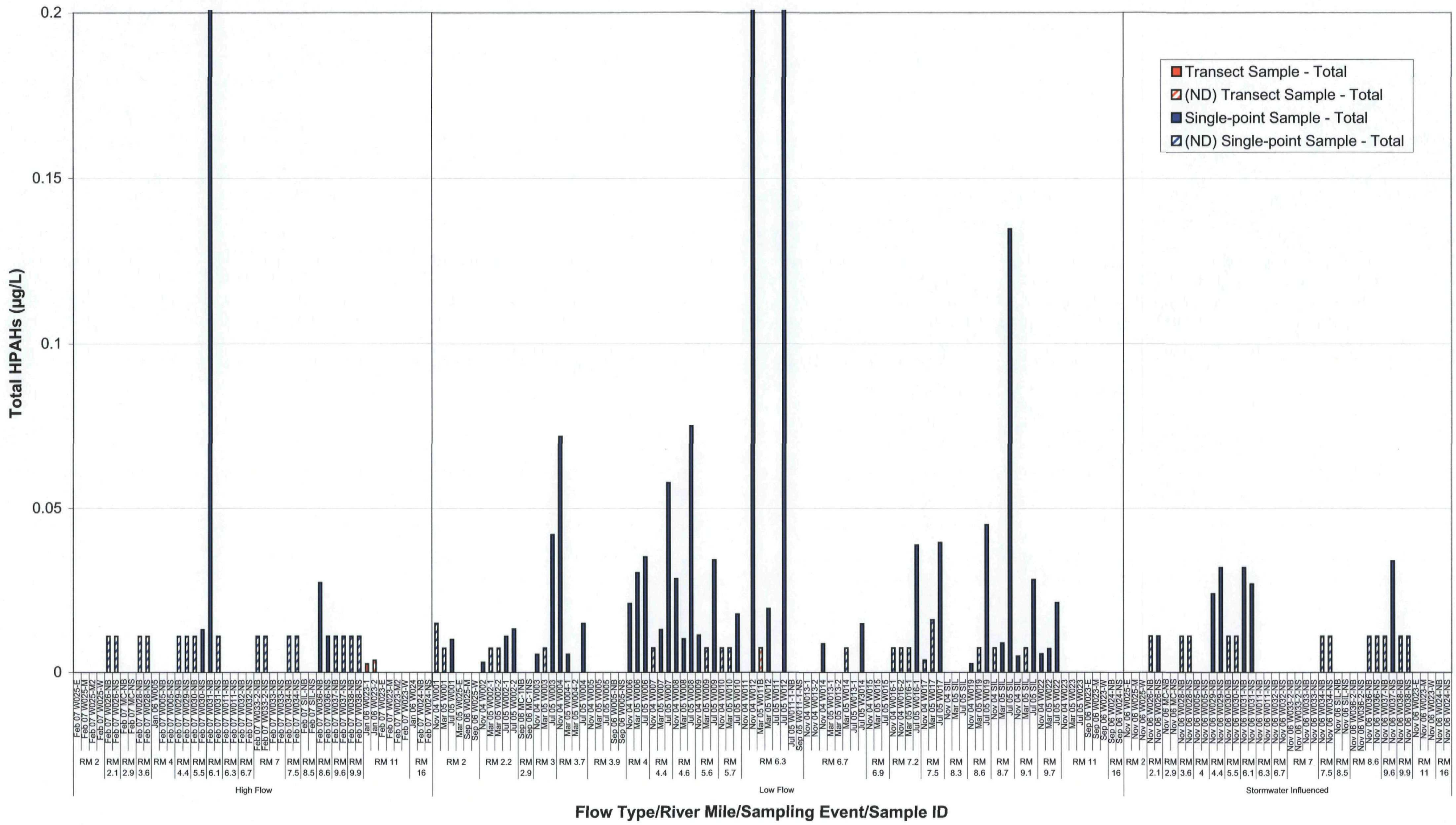

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Figure D3.1-22
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Total High Molecular Weight PAH Concentrations in Surface Water, RM 2-16 (Peristaltic) (scale zoomed)

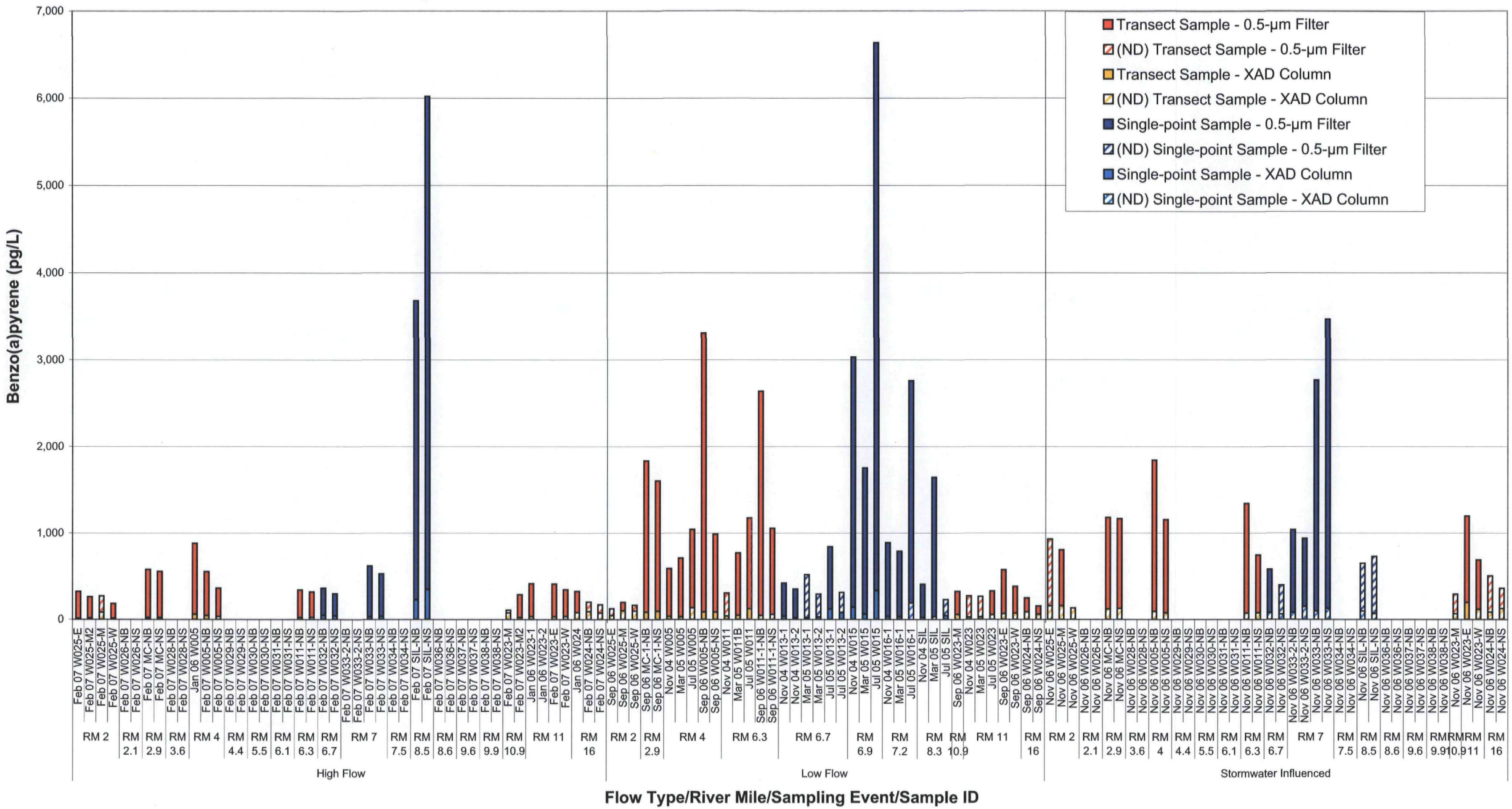

Figure D3.1-23
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Benzo(a)pyrene Concentrations
in Surface Water, RM 2-16 (XAD)

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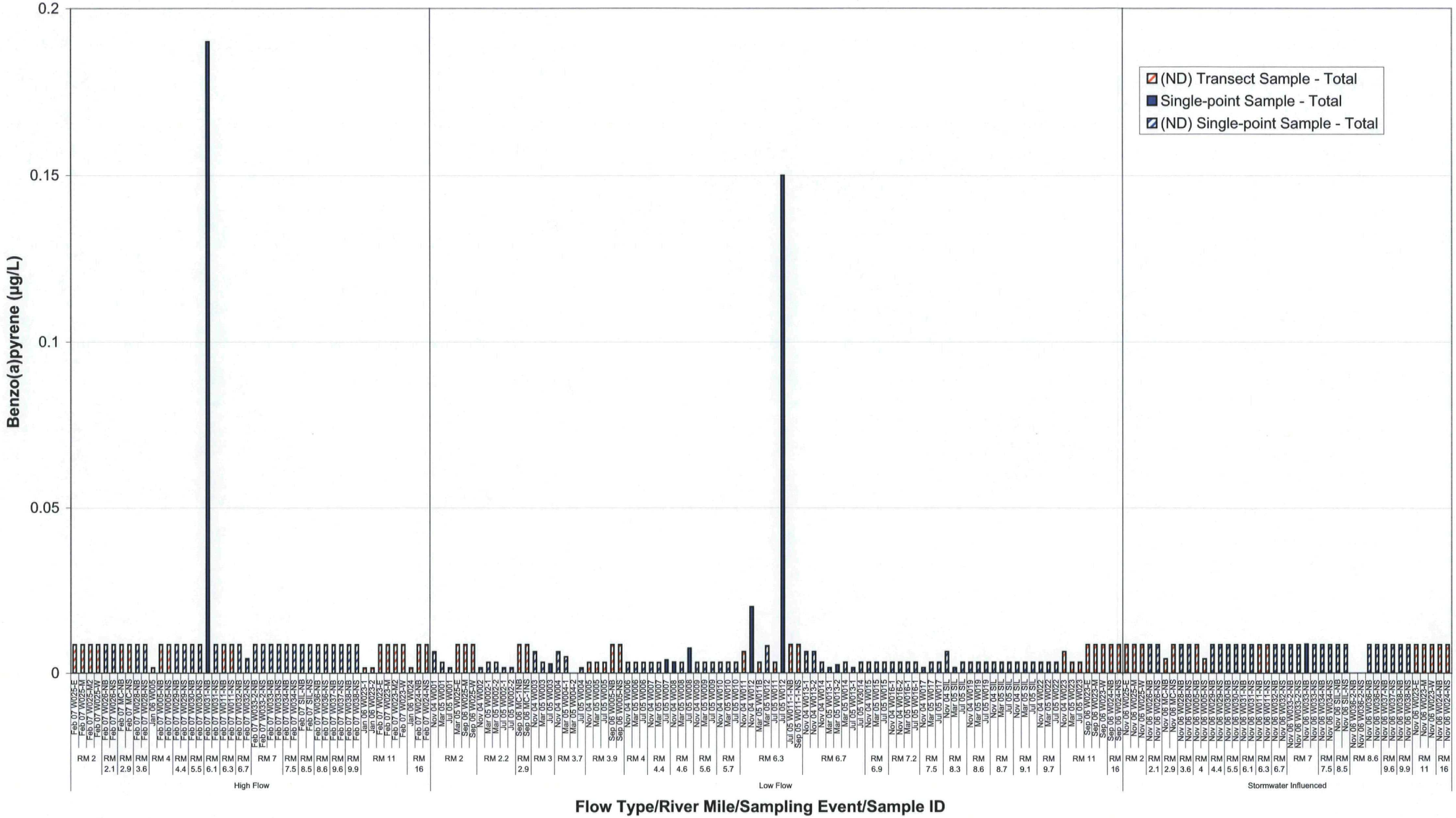

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Figure D3.1-24
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Benzo(a)pyrene Concentrations in Surface Water, RM 2-16 (Peristaltic)

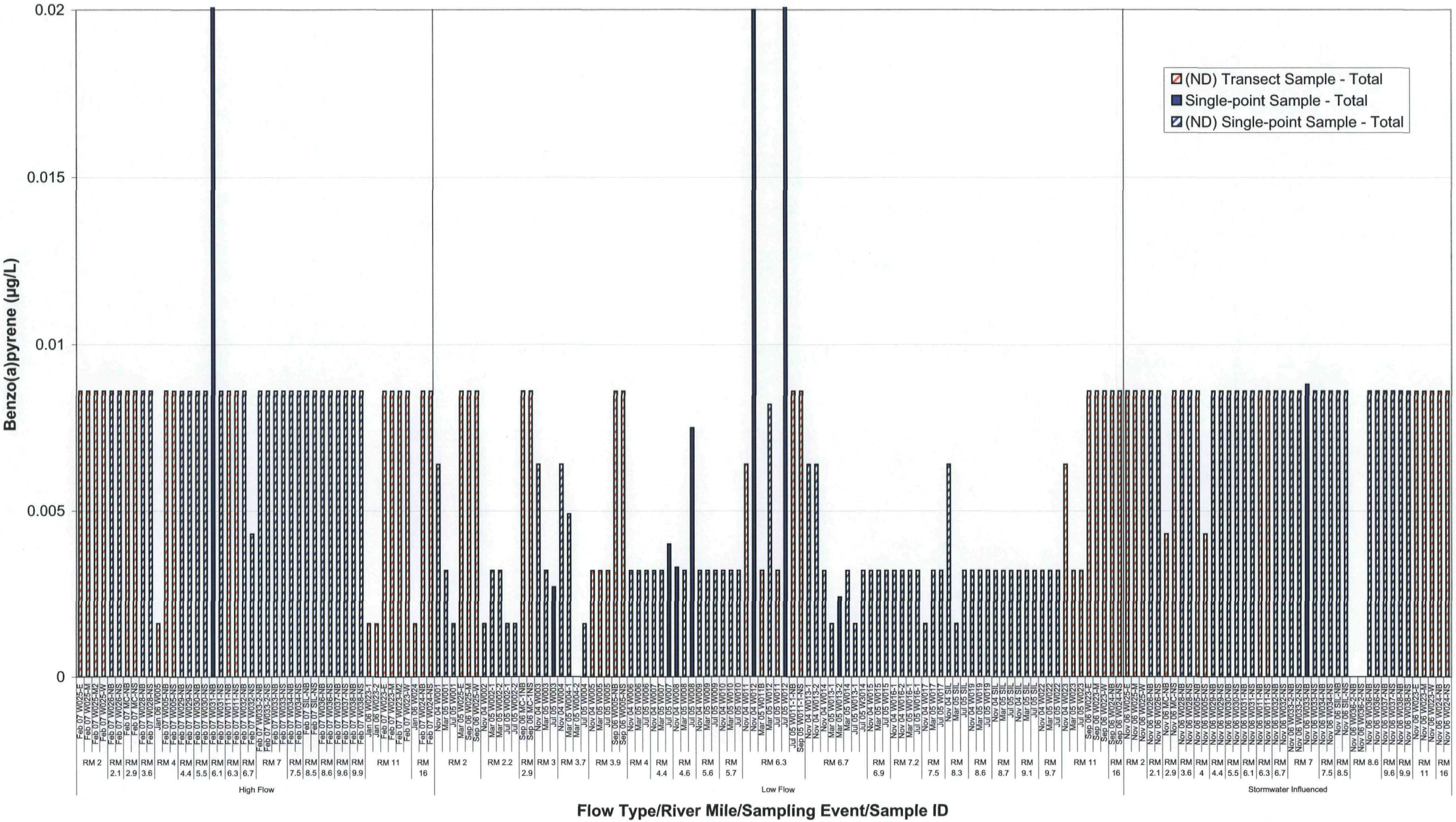

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Figure D3.1-25
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Benzo(a)pyrene Concentrations in Surface Water, RM 2-16 (Peristaltic) (scale zoomed)

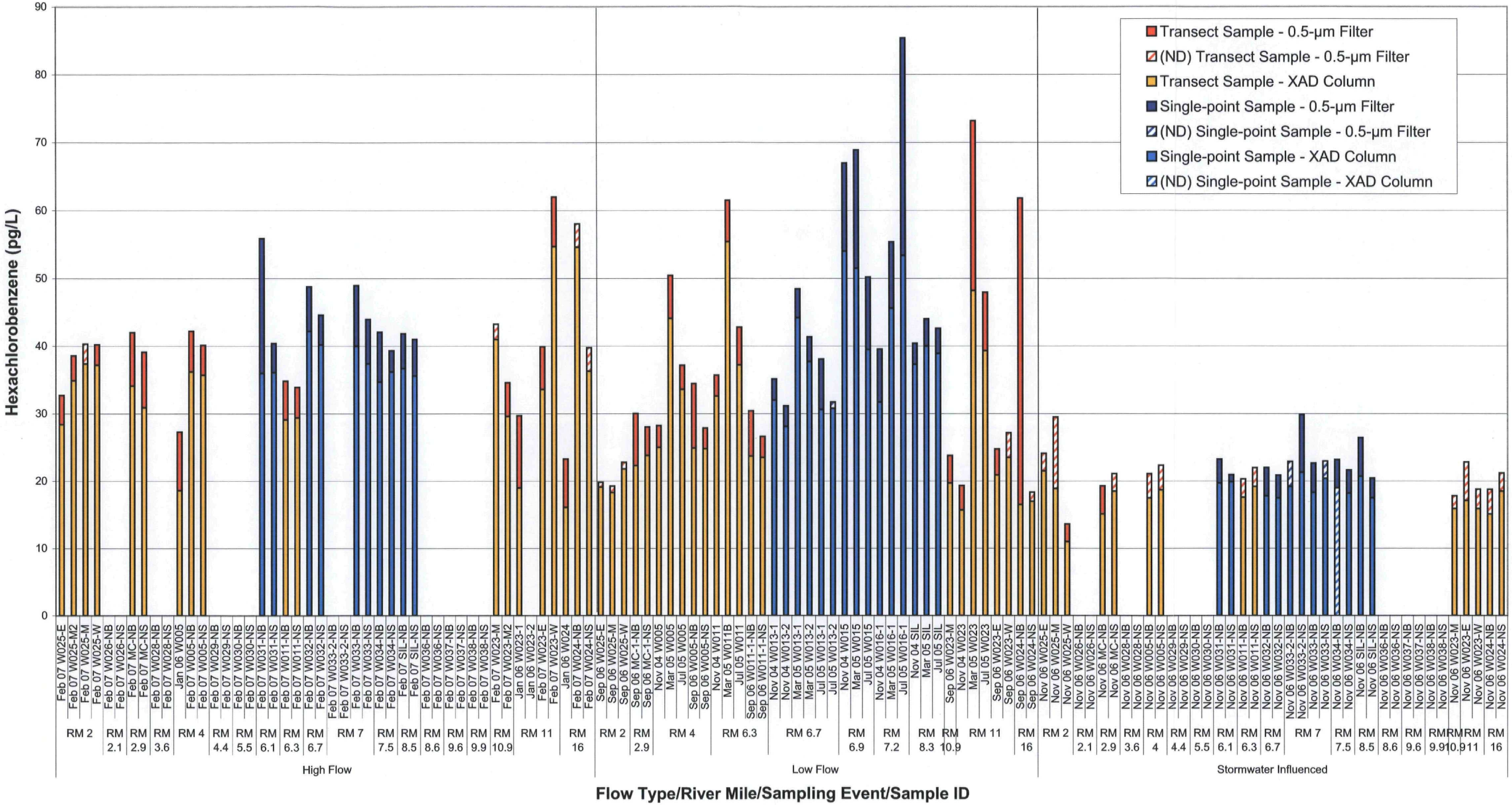

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Figure D3.1-26

Portland Harbor RI/FS

Draft Remedial Investigation Report

Histogram of Hexachlorobenzene Concentrations in Surface Water, RM 2-16 (XAD)

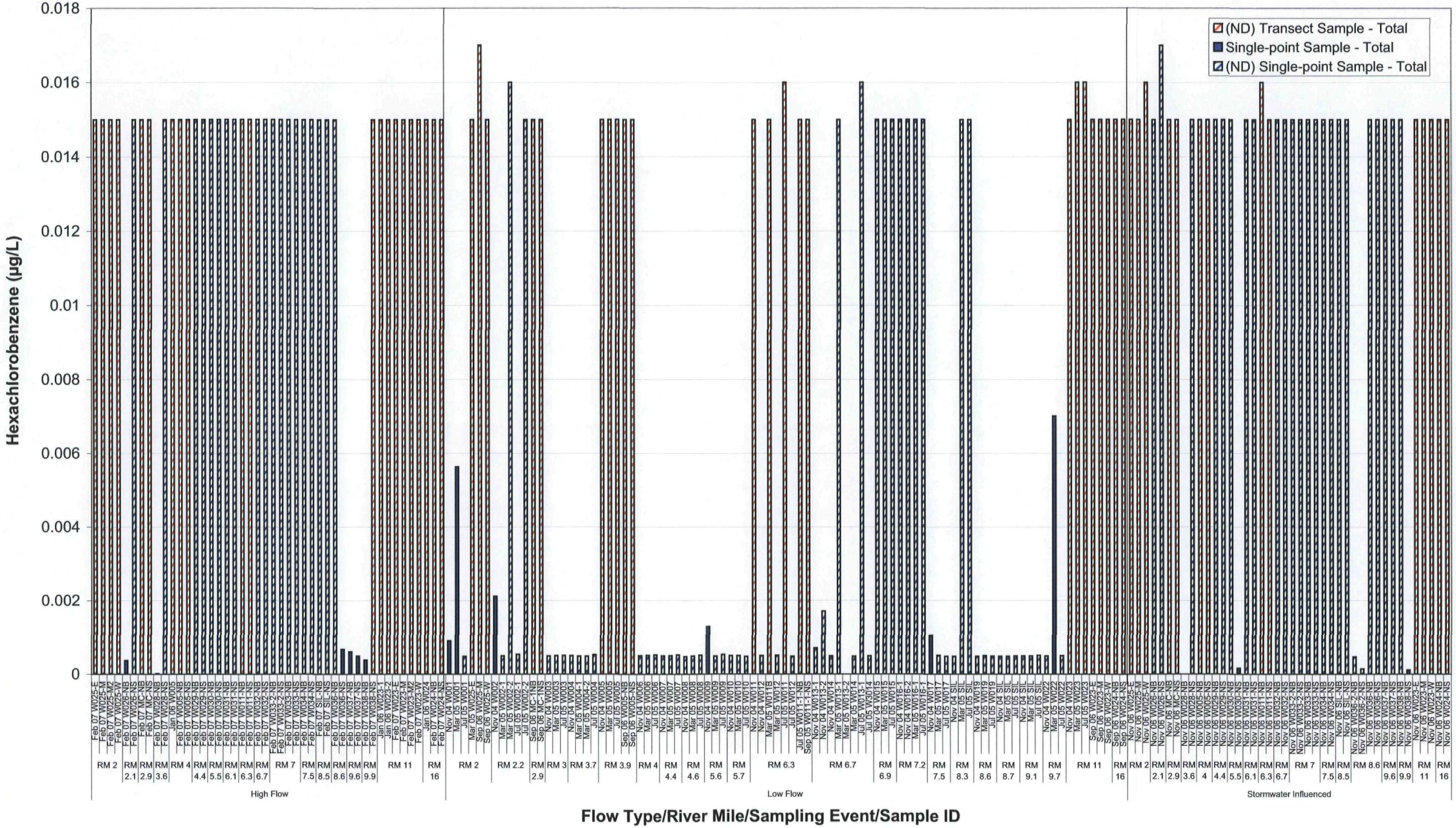

Figure D3.1-27
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Hexachlorobenzene Concentrations
in Surface Water, RM 2-16 (Peristaltic)

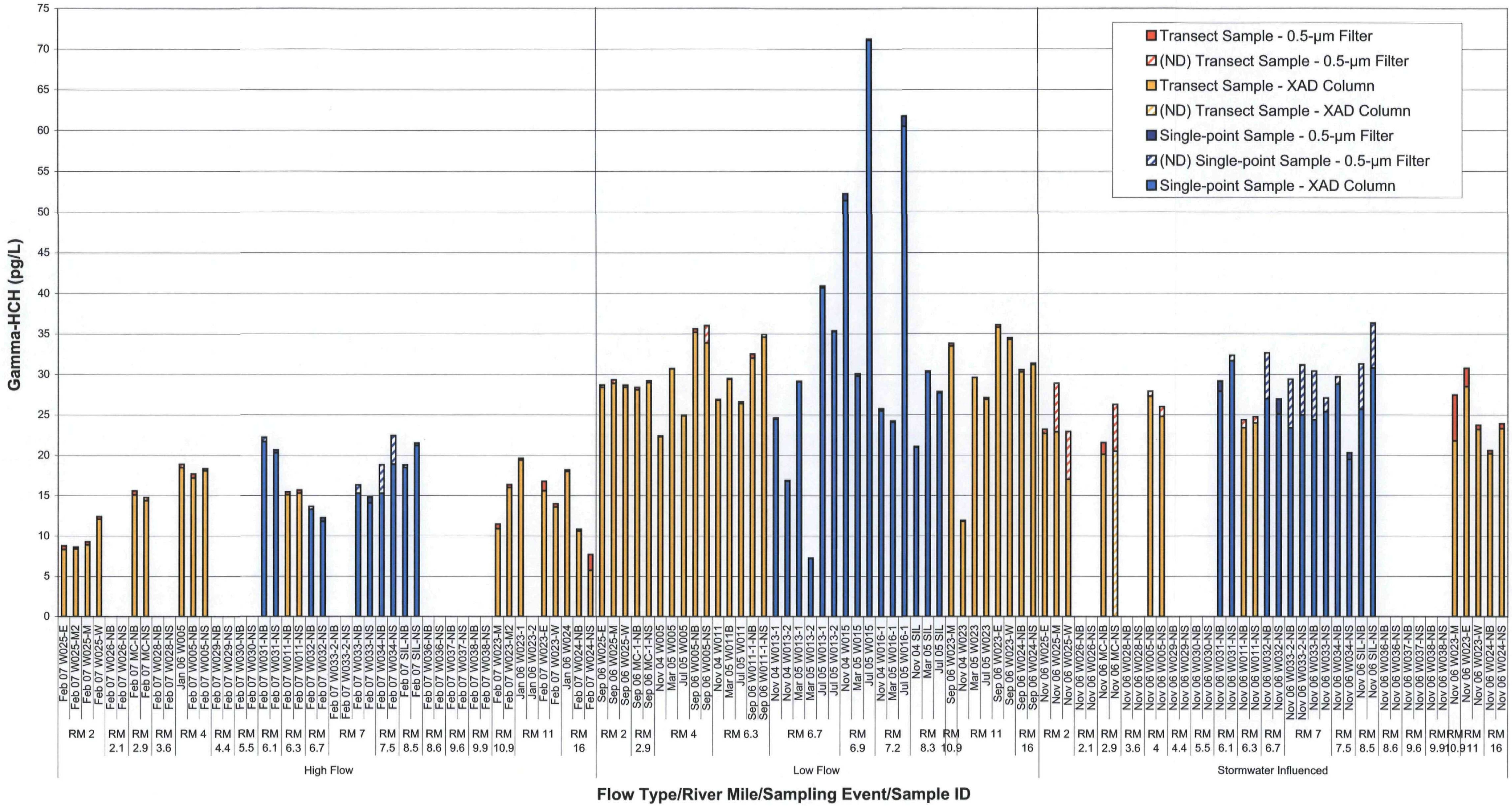

Figure D3.1-28
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of gamma-Hexachlorocyclohexane Concentrations in Surface Water, RM 2-16 (XAD)

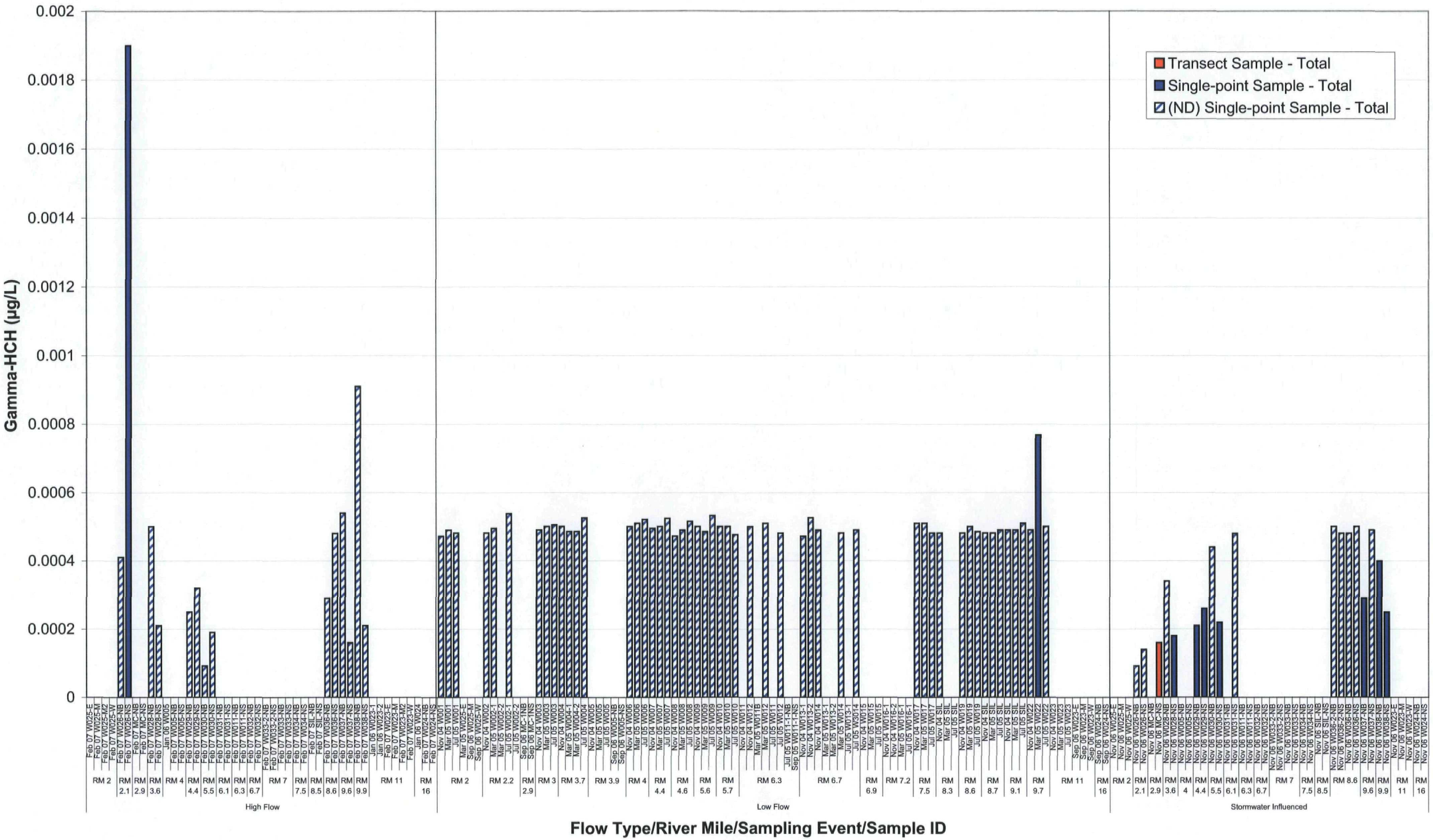

Figure D3.1-29
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of gamma-Hexachlorocyclohexane Concentrations in Surface Water, RM 2-16 (Peristaltic)

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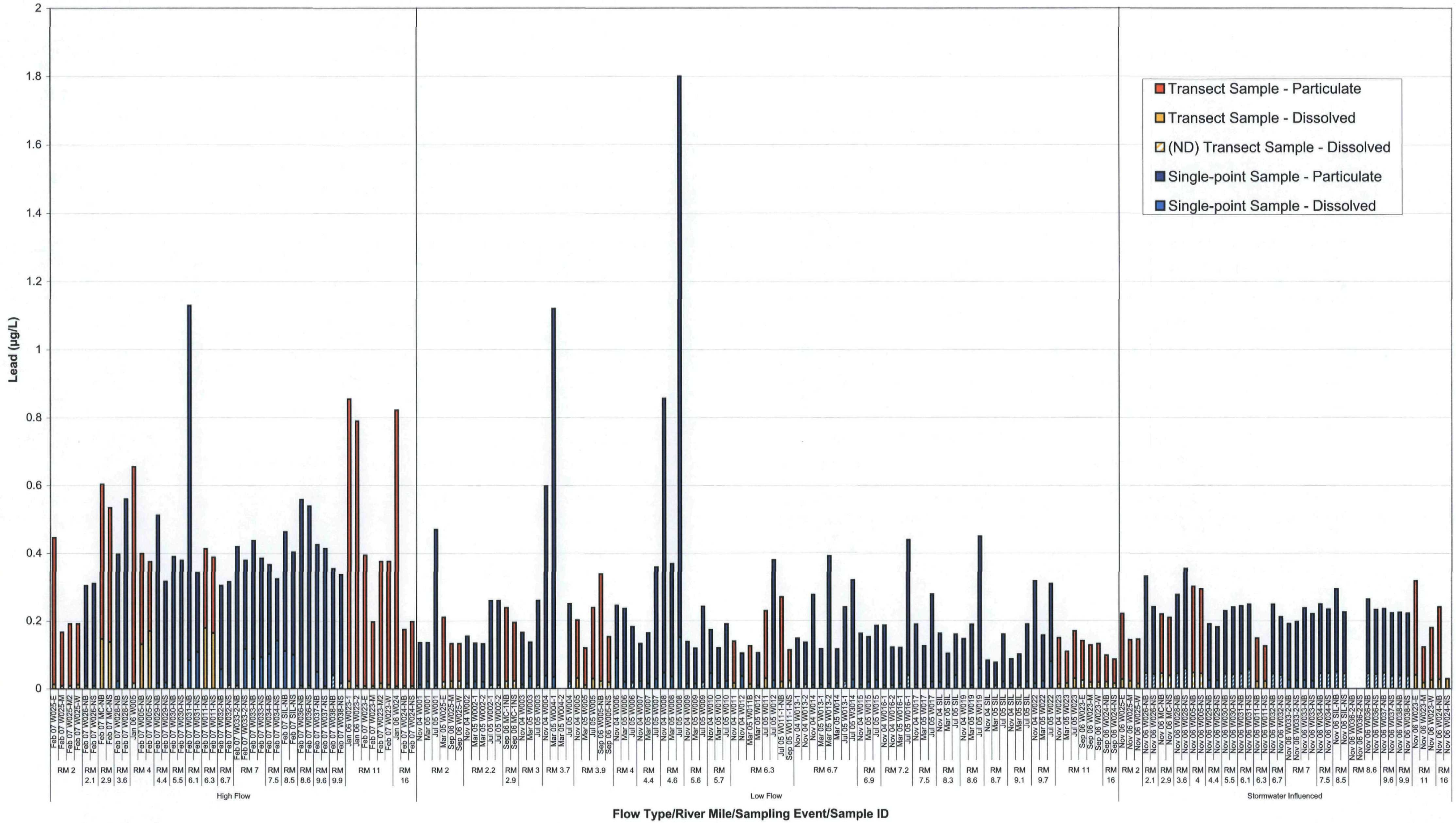

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Figure D3.1-30
Portland Harbor RI/FS
Draft Remedial Investigation Report
Histogram of Lead Concentrations
in Surface Water, RM 2-16 (Peristaltic)

Appendix D3.2

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PORTLAND HARBOR RI/FS
REMEDIAL INVESTIGATION REPORT

APPENDIX D3.2
SURFACE WATER SUMMARY STATISTICS FOR ALL ANALYTES (ON CD)

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Appendix D4

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PORTLAND HARBOR RI/FS

REMEDIAL INVESTIGATION REPORT

APPENDIX D4
TRANSITION ZONE WATER SUMMARY STATISTICS FOR ALL ANALYTES
(ON CD)

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PORTLAND HARBOR RI/FS

REMEDIAL INVESTIGATION REPORT

APPENDIX D5
BIOTA
(FISH, SHELLFISH, AND INVERTEBRATES)

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Appendix D5.1

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PORTLAND HARBOR RI/FS

REMEDIAL INVESTIGATION REPORT

APPENDIX D5.1
BIOTA SUMMARY STATISTICS FOR ALL ANALYTES (ON CD)

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Appendix D5.2

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PORTLAND HARBOR RI/FS

REMEDIAL INVESTIGATION REPORT

APPENDIX D5.2
BIOTA BOX-WHISKER PLOTS AND SCATTER PLOTS (FOR ICS NOT PRESENTED IN MAIN REPORT)

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LIST OF FIGURES

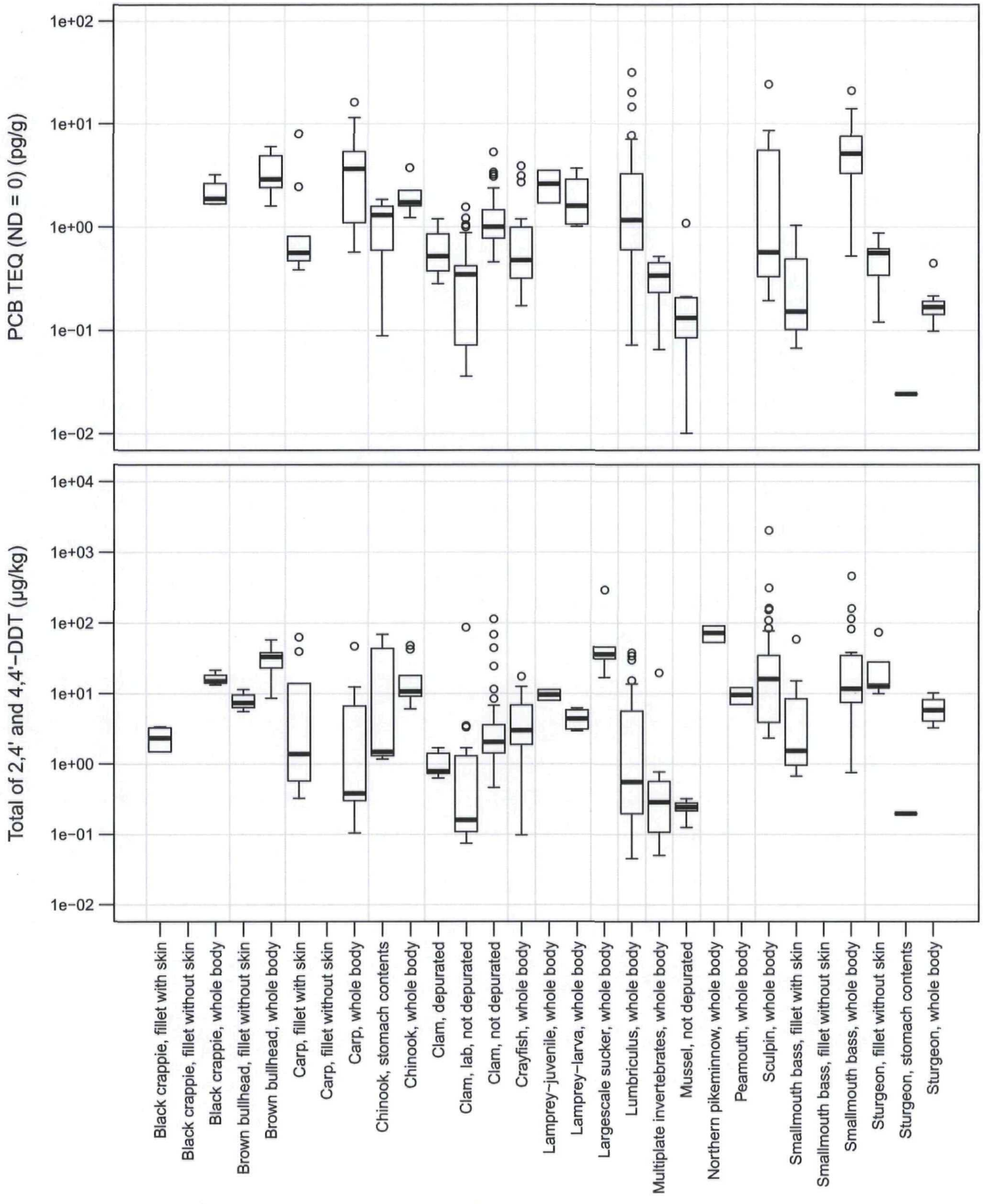

Figure D5.2-1
Portland Harbor RI/FS
Draft Remedial Investigation Report
Box-Whisker Plot of Detected PCB TEQ (ND = 0)
and Total DDT Isomers in Biota
by Sample Type, RM 0.8-12.2

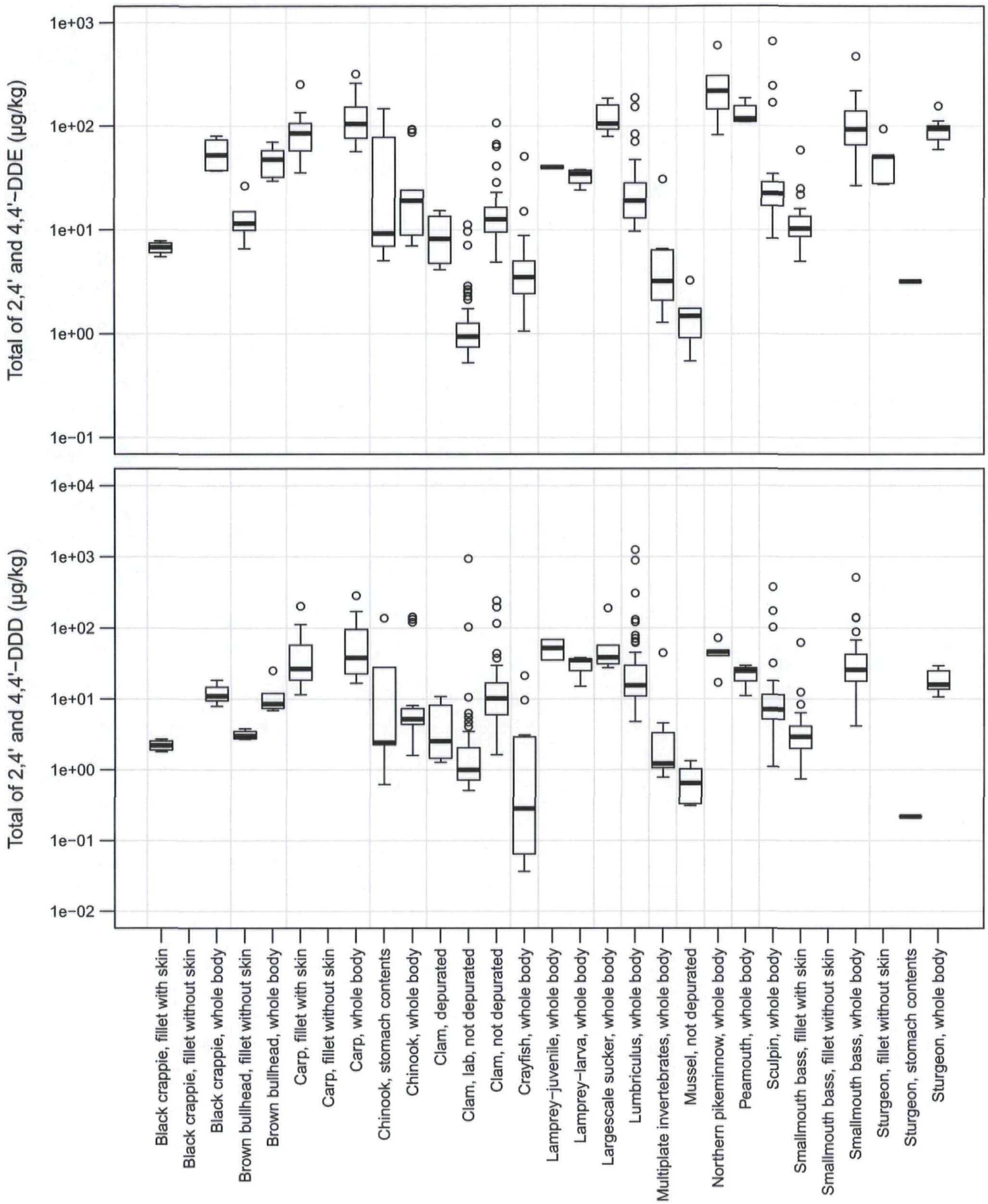

Figure D5.2-2
Portland Harbor RI/FS
Draft Remedial Investigation Report
Box-Whisker Plot of Detected Total DDE Isomers and Total DDD Isomers in Biota by Sample Type, RM 0.8-12.2

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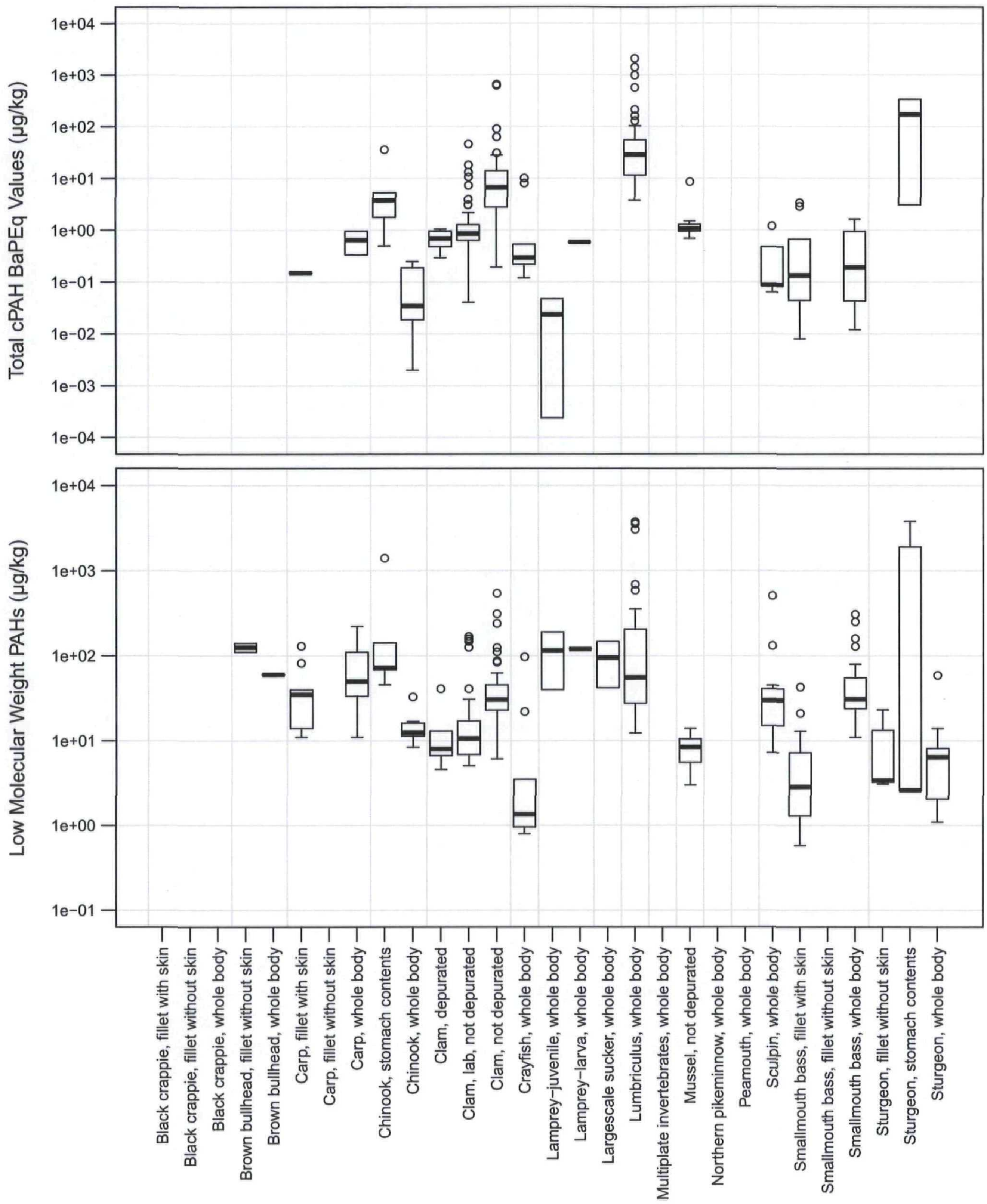

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Figure D5.2-3
Portland Harbor RI/FS
Draft Remedial Investigation Report
Box-Whisker Plot of Detected Total cPAH BaPEq Values
and Low Molecular Weight PAHs in Biota
by Sample Type, RM 0.8-12.2

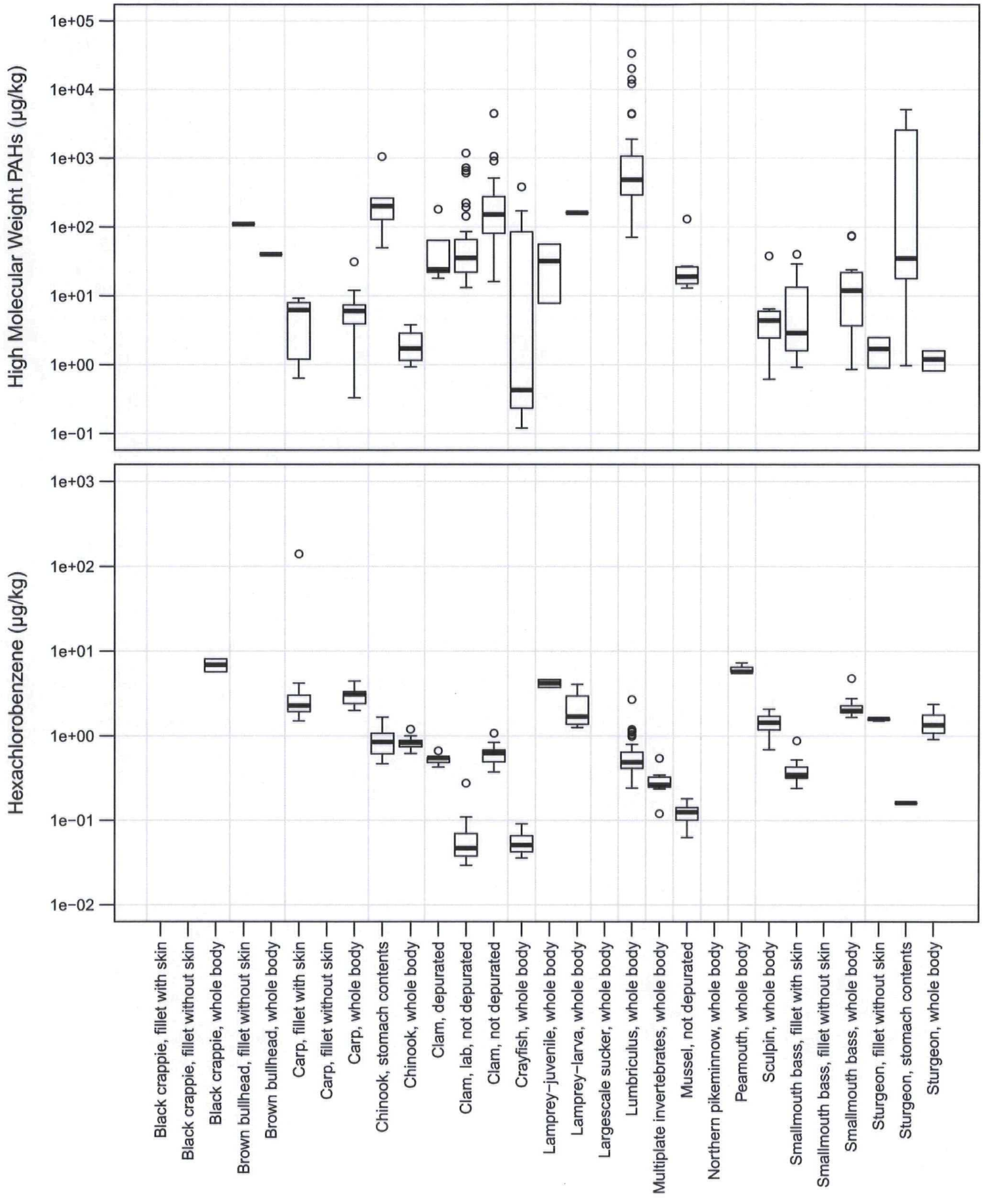

Figure D5.2-4
Portland Harbor RI/FS
Draft Remedial Investigation Report
Box-Whisker Plot of Detected High Molecular Weight PAHs
and Hexachlorobenzene in Biota
by Sample Type, RM 0.8-12.2

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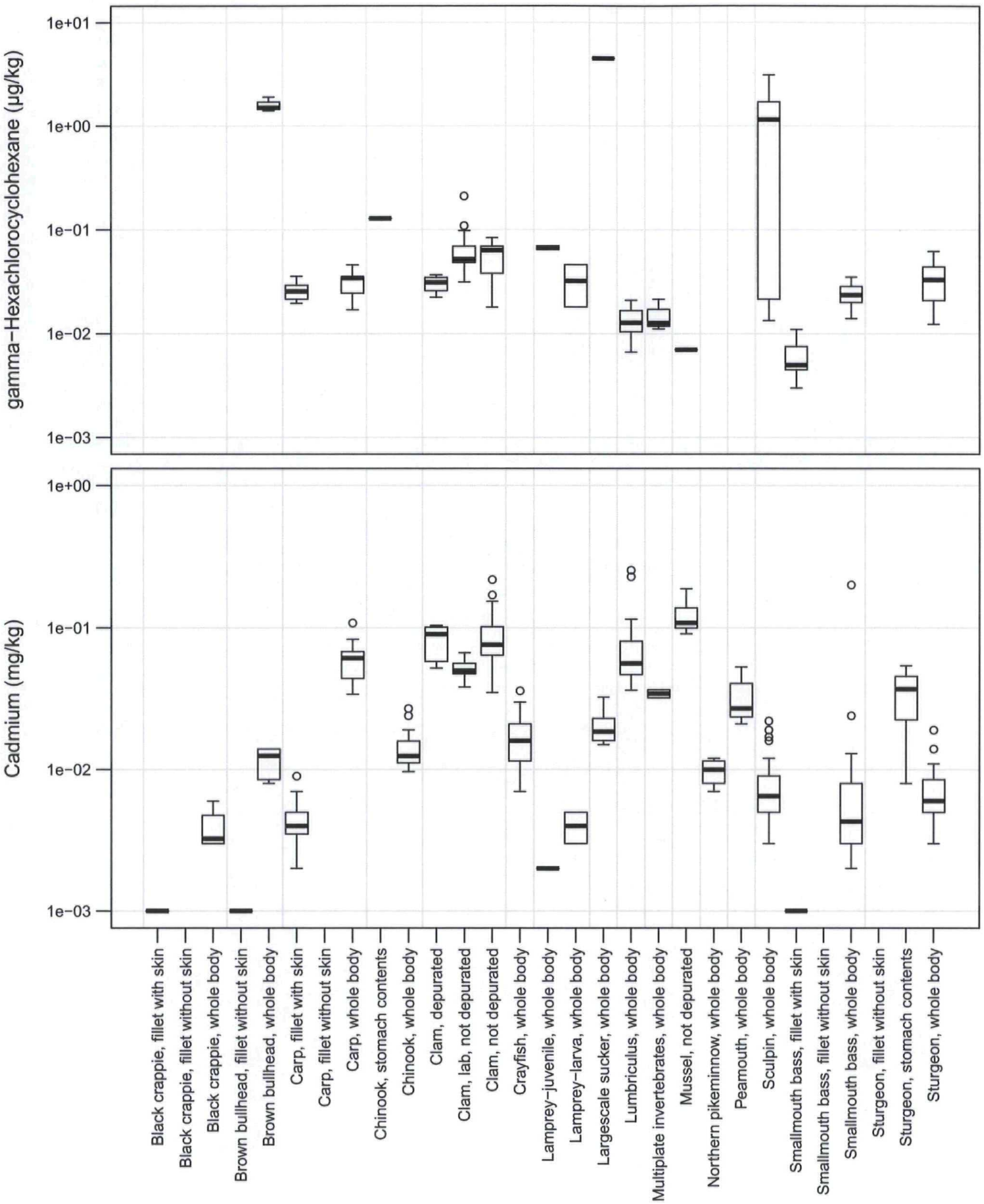

Figure D5.2−5
Portland Harbor RI/FS
Draft Remedial Investigation Report
Box−Whisker Plot of Detected Cadmium
and gamma−Hexachlorocyclohexane in Biota
by Sample Type, RM 0.8−12.2

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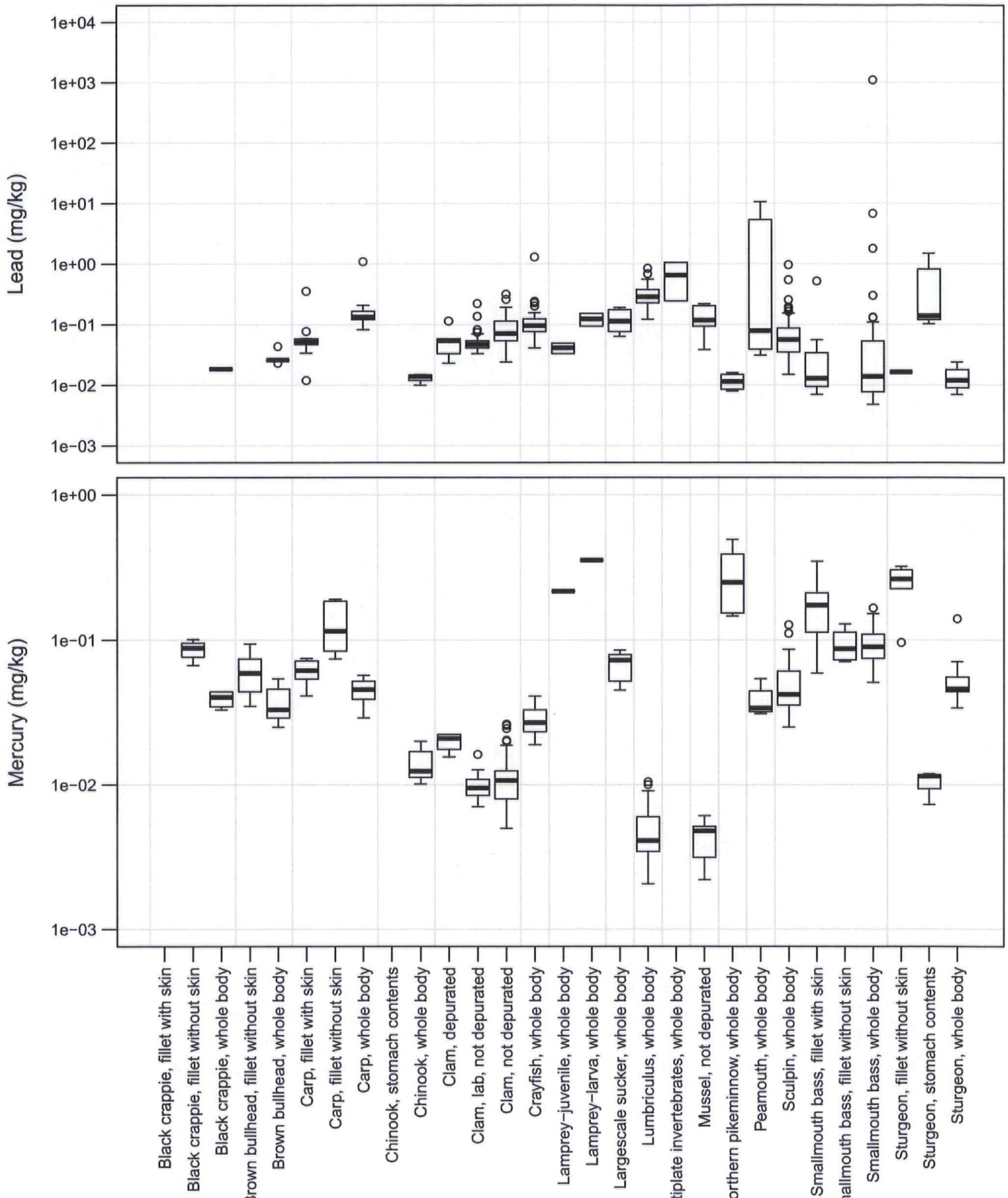

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Figure D5.2-6
Portland Harbor RI/FS
Draft Remedial Investigation Report
Box-Whisker Plot of Detected Lead and Mercury in Biota by Sample Type, RM 0.8-12.2

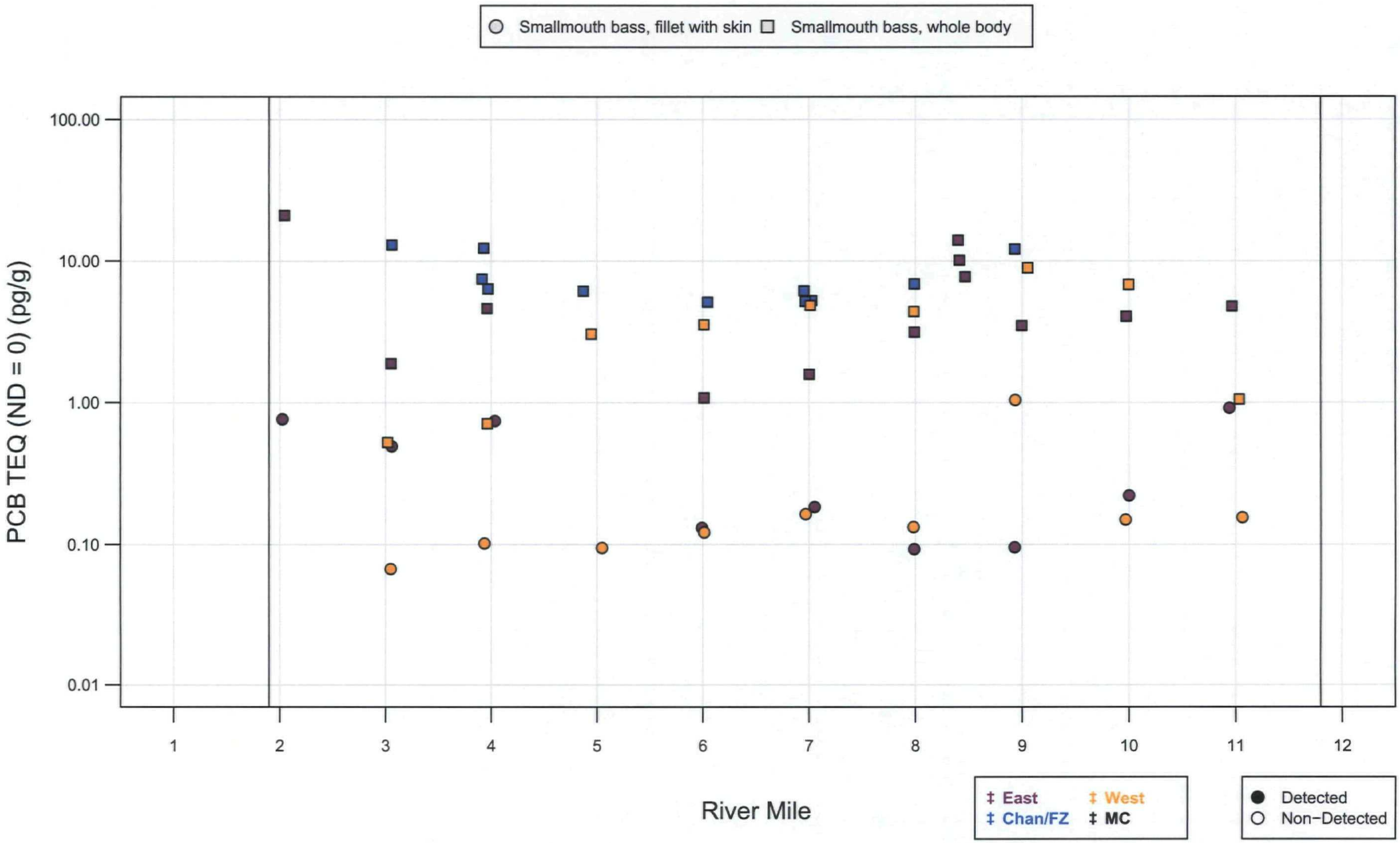

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Figure D5.2−7a

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of PCB TEQ (ND = 0) in
Tissue Samples by River Mile, RM 0.8−12.2

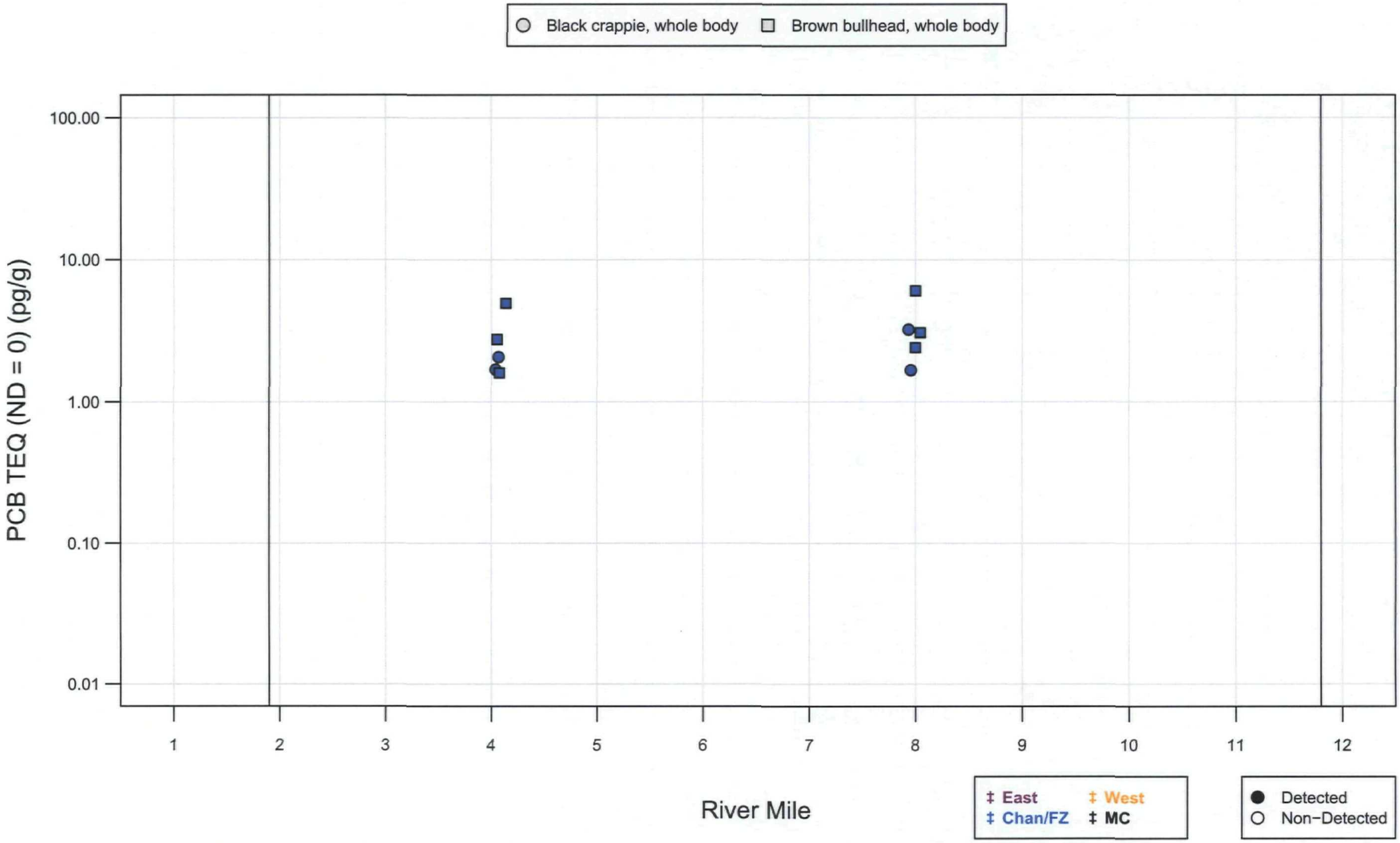

Figure D5.2-7b

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of PCB TEQ (ND = 0) in Tissue Samples by River Mile, RM 0.8-12.2

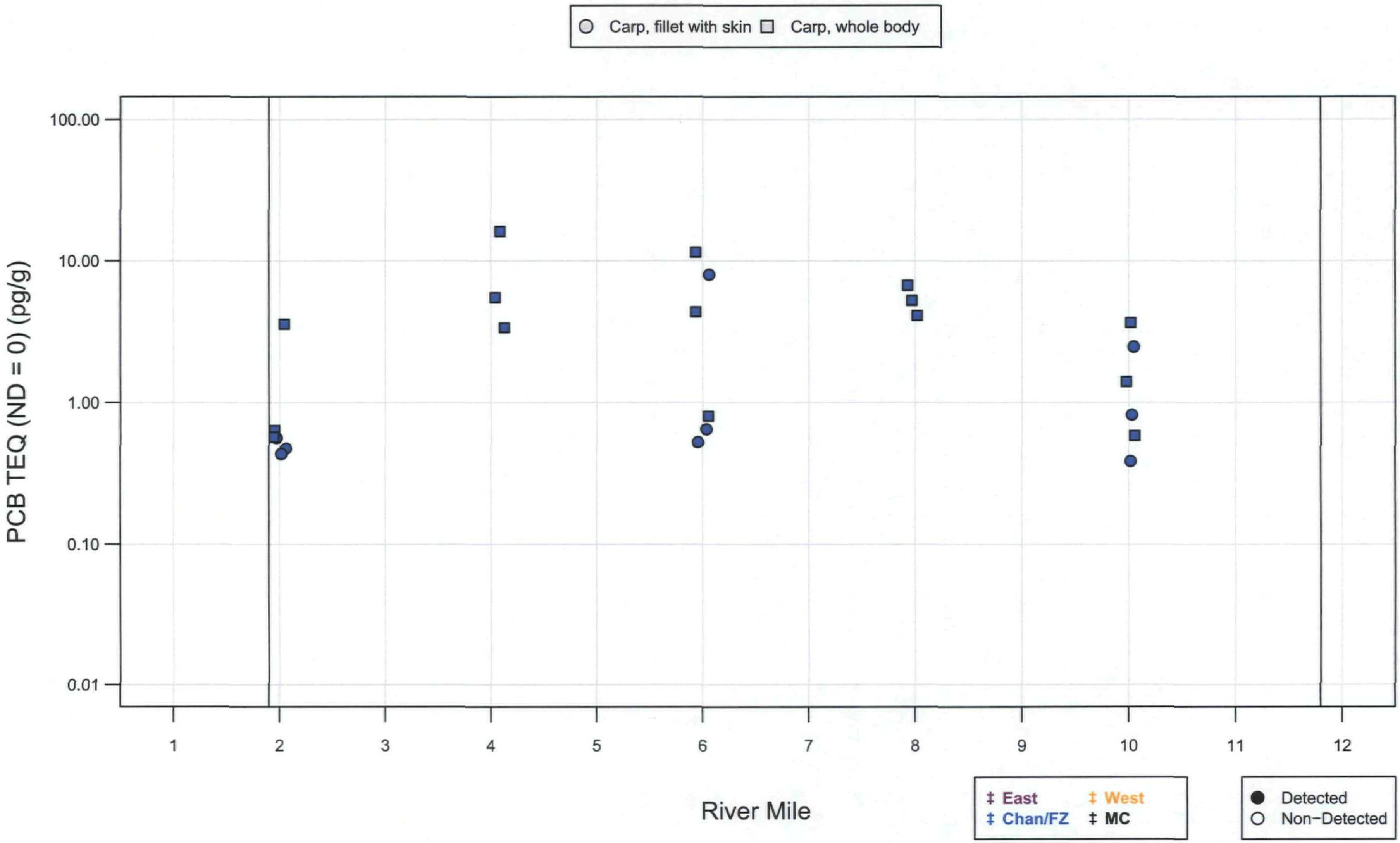

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Figure D5.2-7c
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of PCB TEQ (ND = 0) in
Tissue Samples by River Mile, RM 0.8-12.2

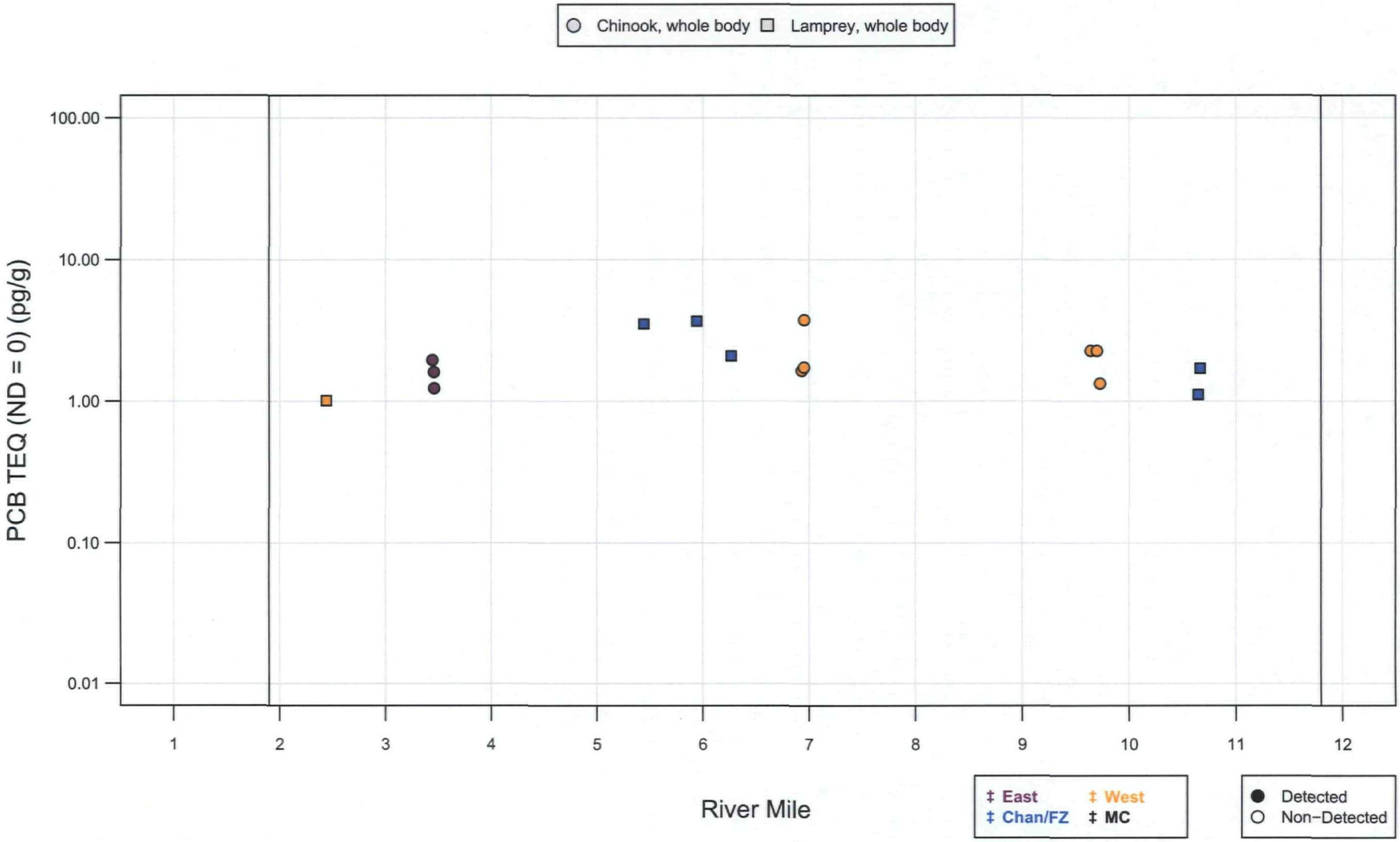

Figure D5.2-7d

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of PCB TEQ (ND = 0) in
Tissue Samples by River Mile, RM 0.8-12.2

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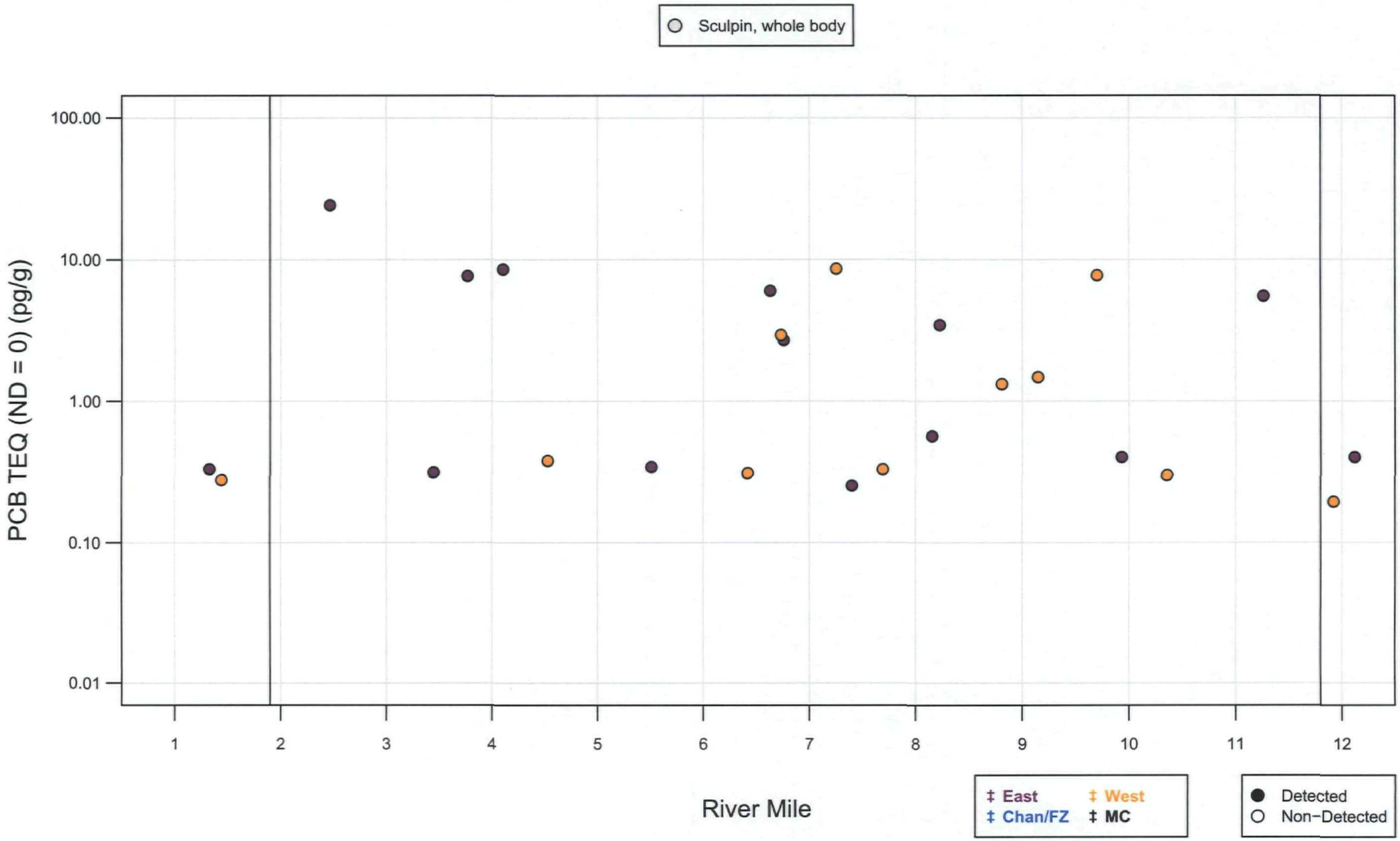

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Figure D5.2-7e

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of PCB TEQ (ND = 0) in
Tissue Samples by River Mile, RM 0.8-12.2

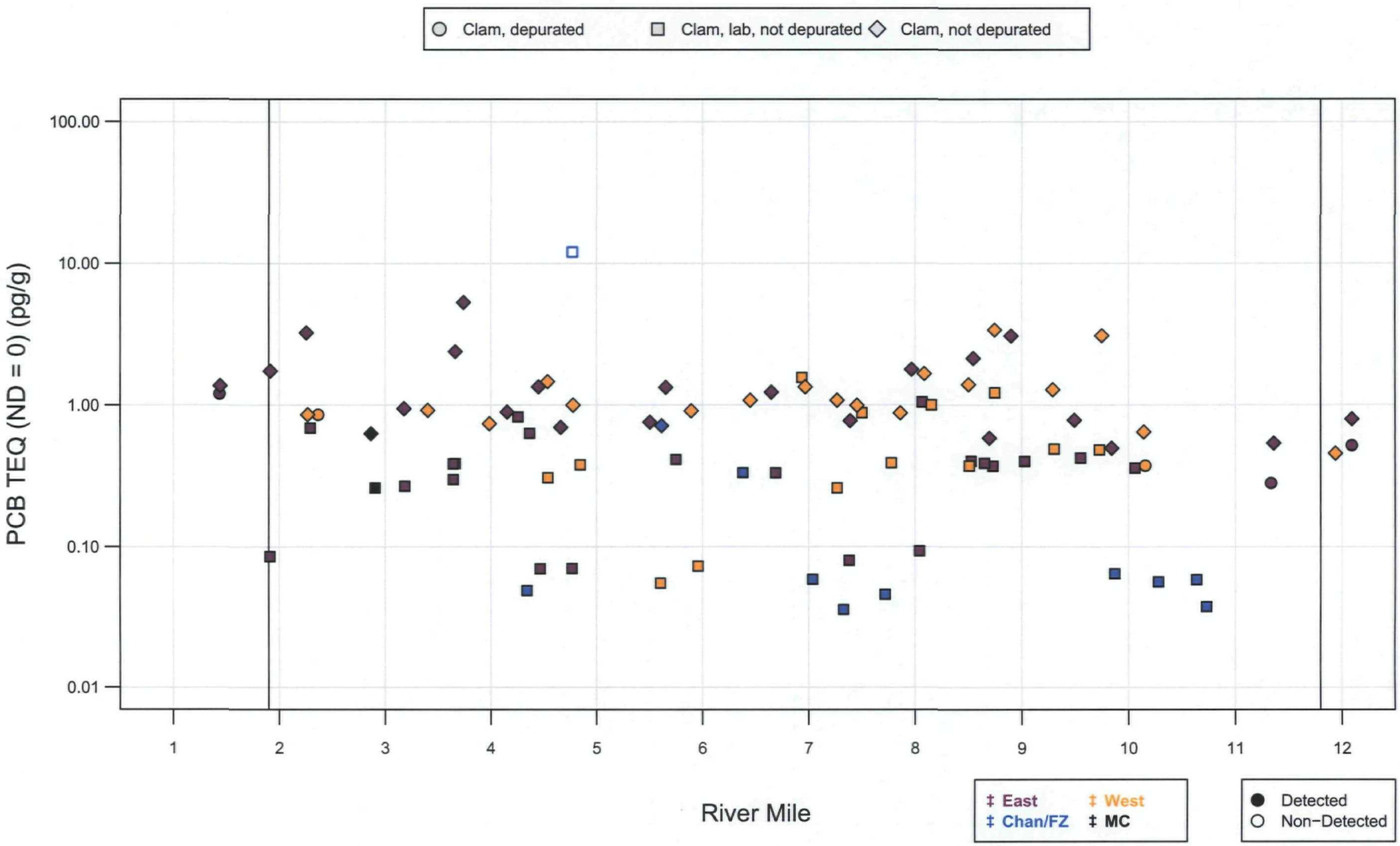

Figure D5.2-7f

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of PCB TEQ (ND = 0) in
Tissue Samples by River Mile, RM 0.8-12.2

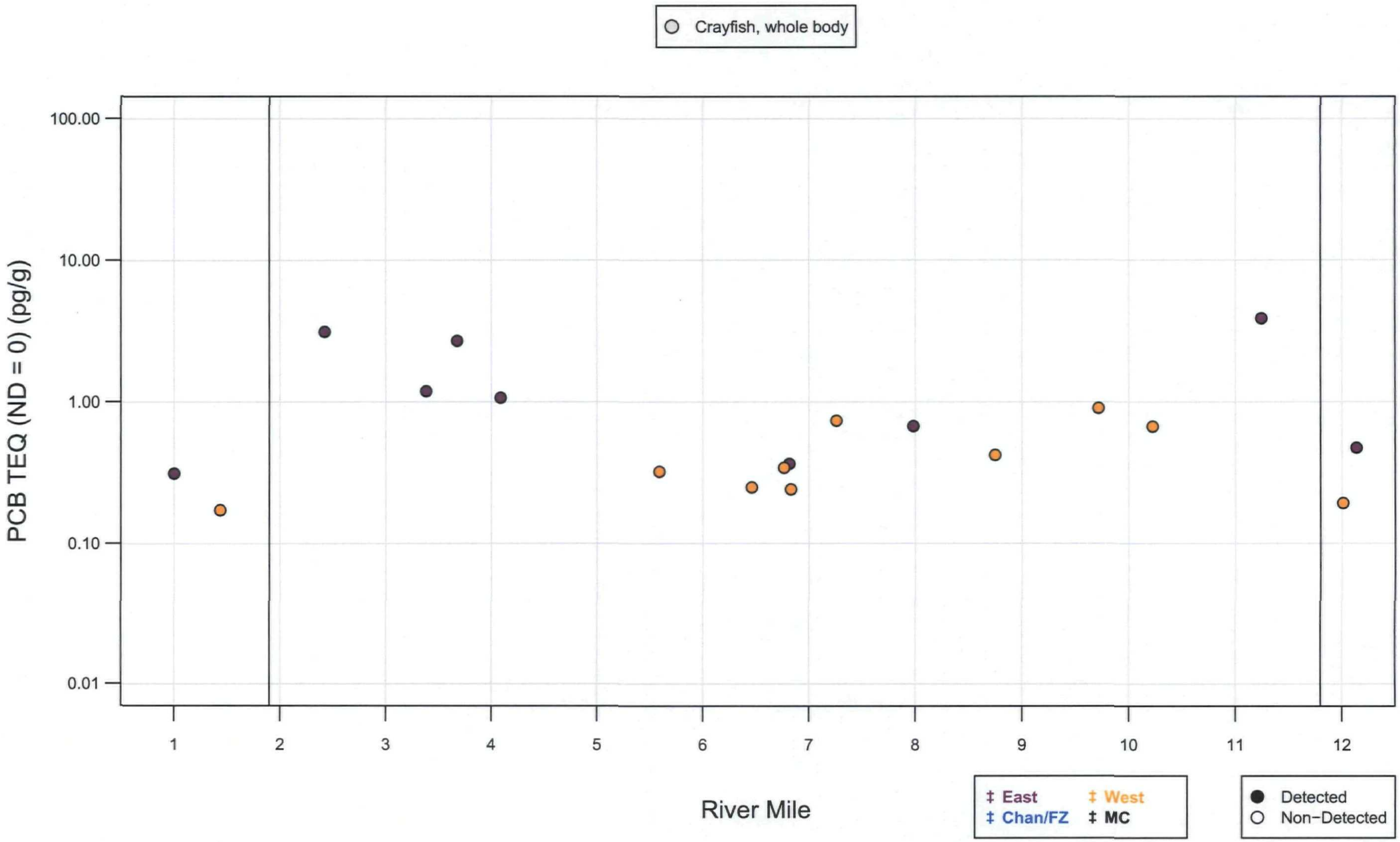

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Figure D5.2-7g

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of PCB TEQ (ND = 0) in
Tissue Samples by River Mile, RM 0.8-12.2

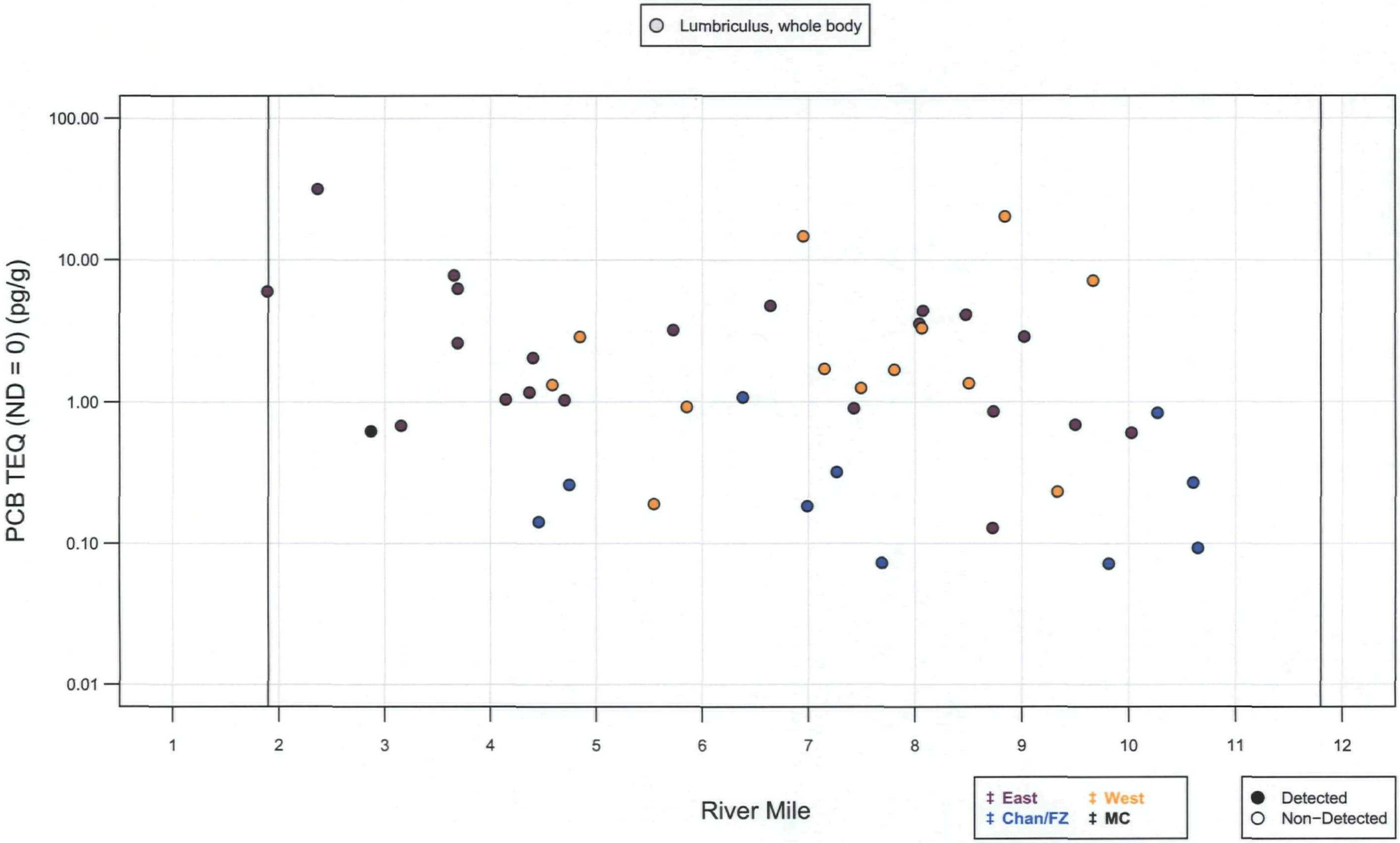

Figure D5.2−7h

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of PCB TEQ (ND = 0) in
Tissue Samples by River Mile, RM 0.8−12.2

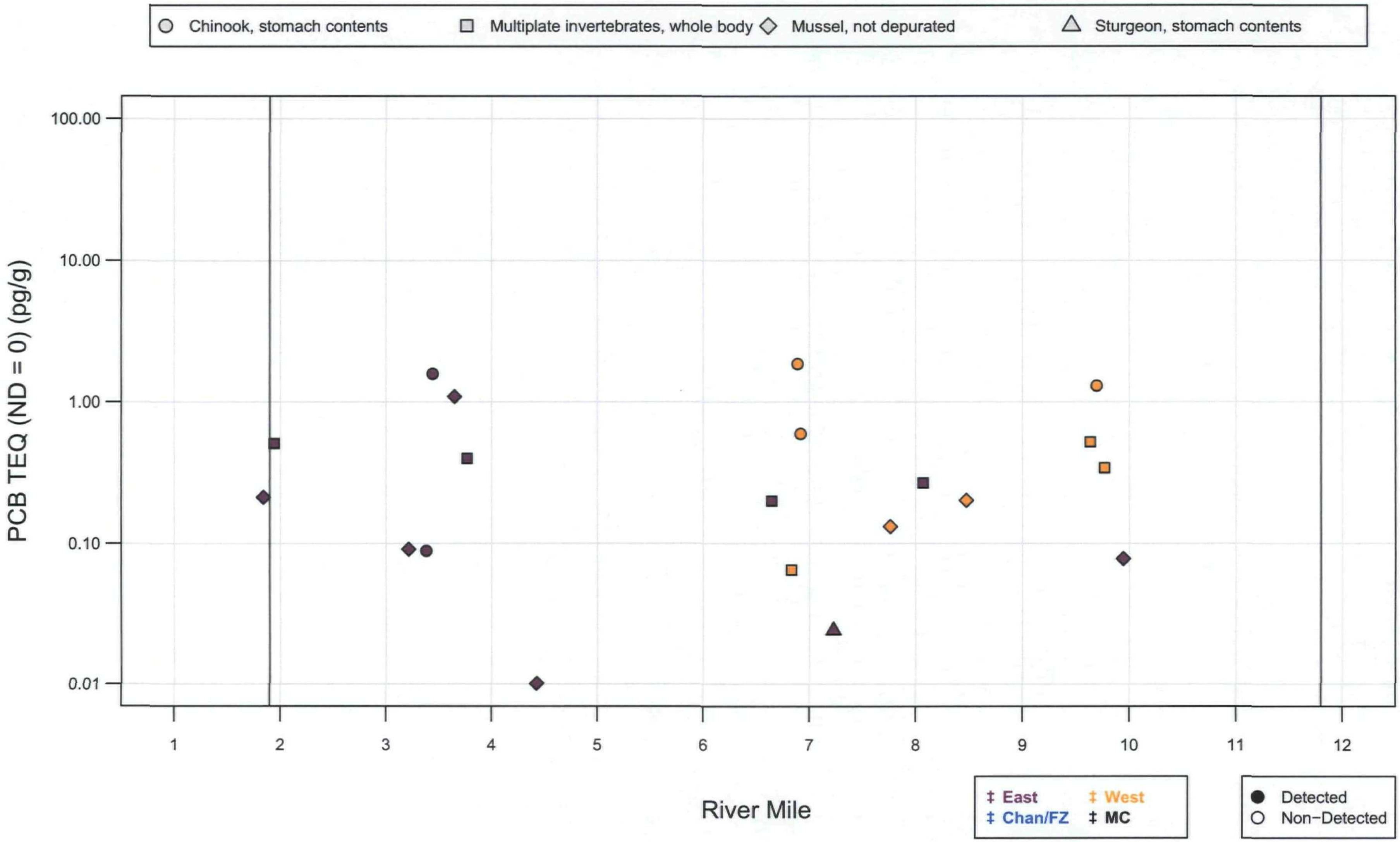

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Figure D5.2-7i
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of PCB TEQ (ND = 0) in Tissue Samples by River Mile, RM 0.8-12.2

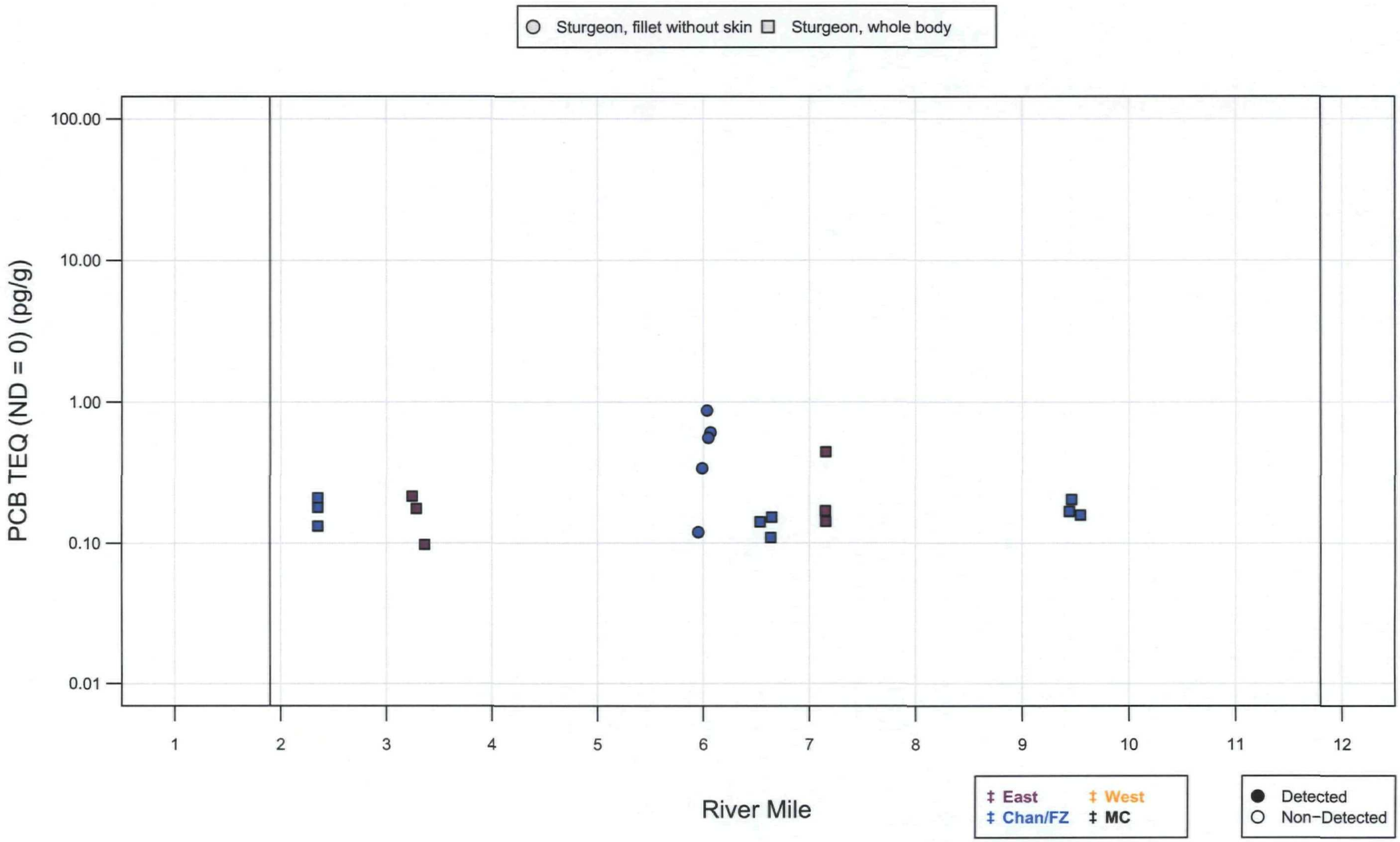

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Figure D5.2−7j

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of PCB TEQ (ND = 0) in
Tissue Samples by River Mile, RM 0.8−12.2

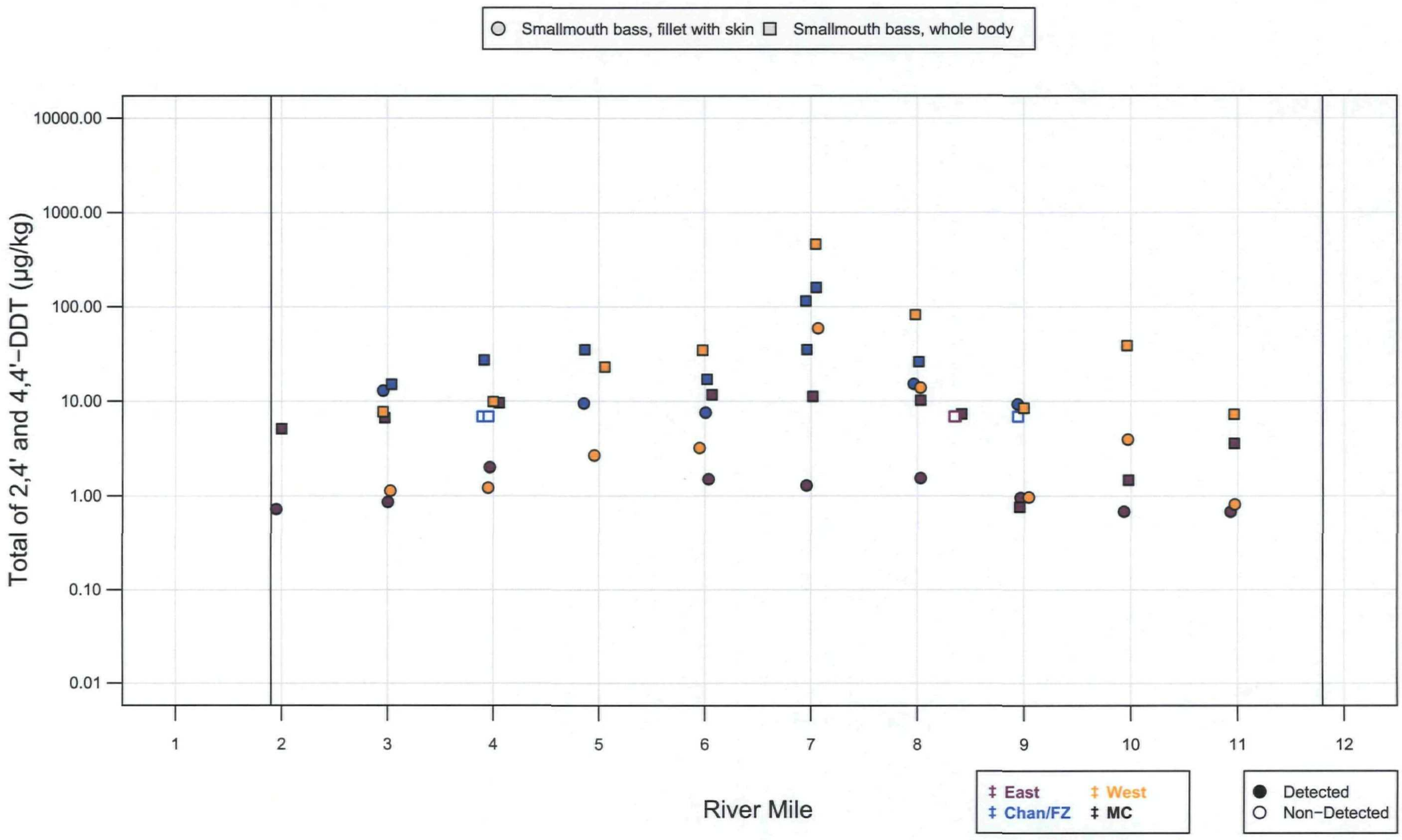

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Figure D5.2-8a
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDT in Tissue Samples by River Mile, RM 0.8-12.2

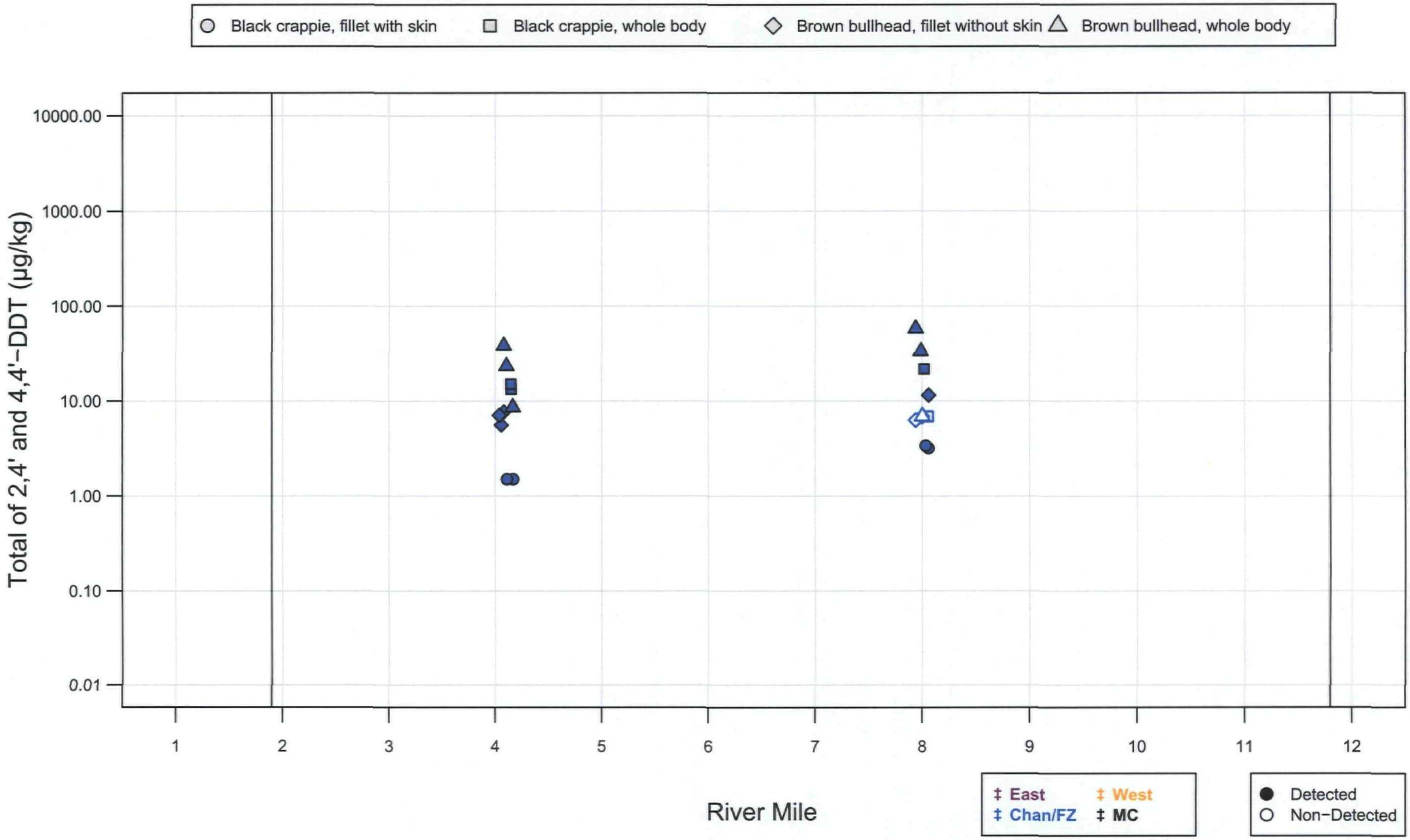

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Figure D5.2−8b
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'−DDT in Tissue Samples by River Mile, RM 0.8−12.2

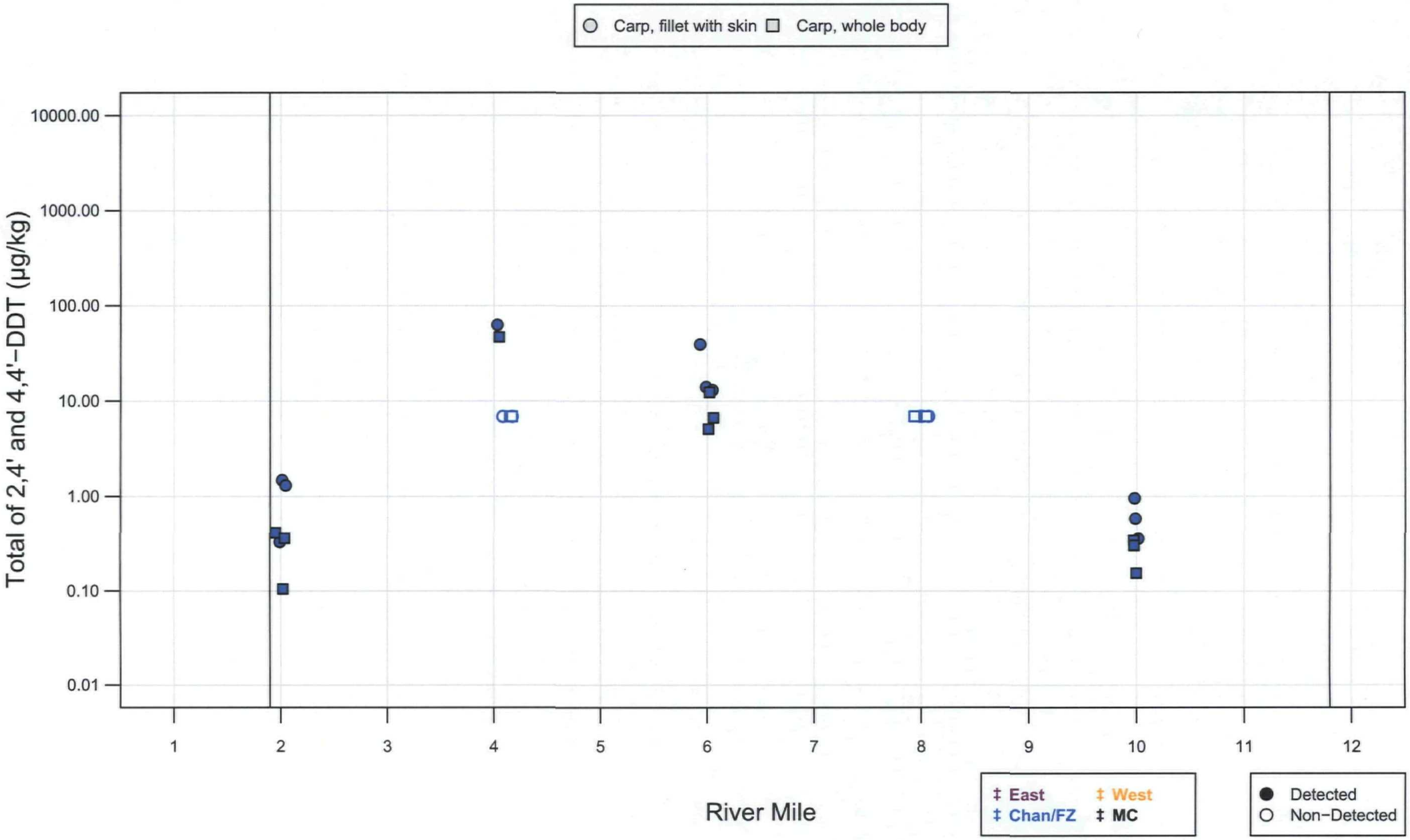

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Figure D5.2-8c

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDT in Tissue Samples by River Mile, RM 0.8-12.2

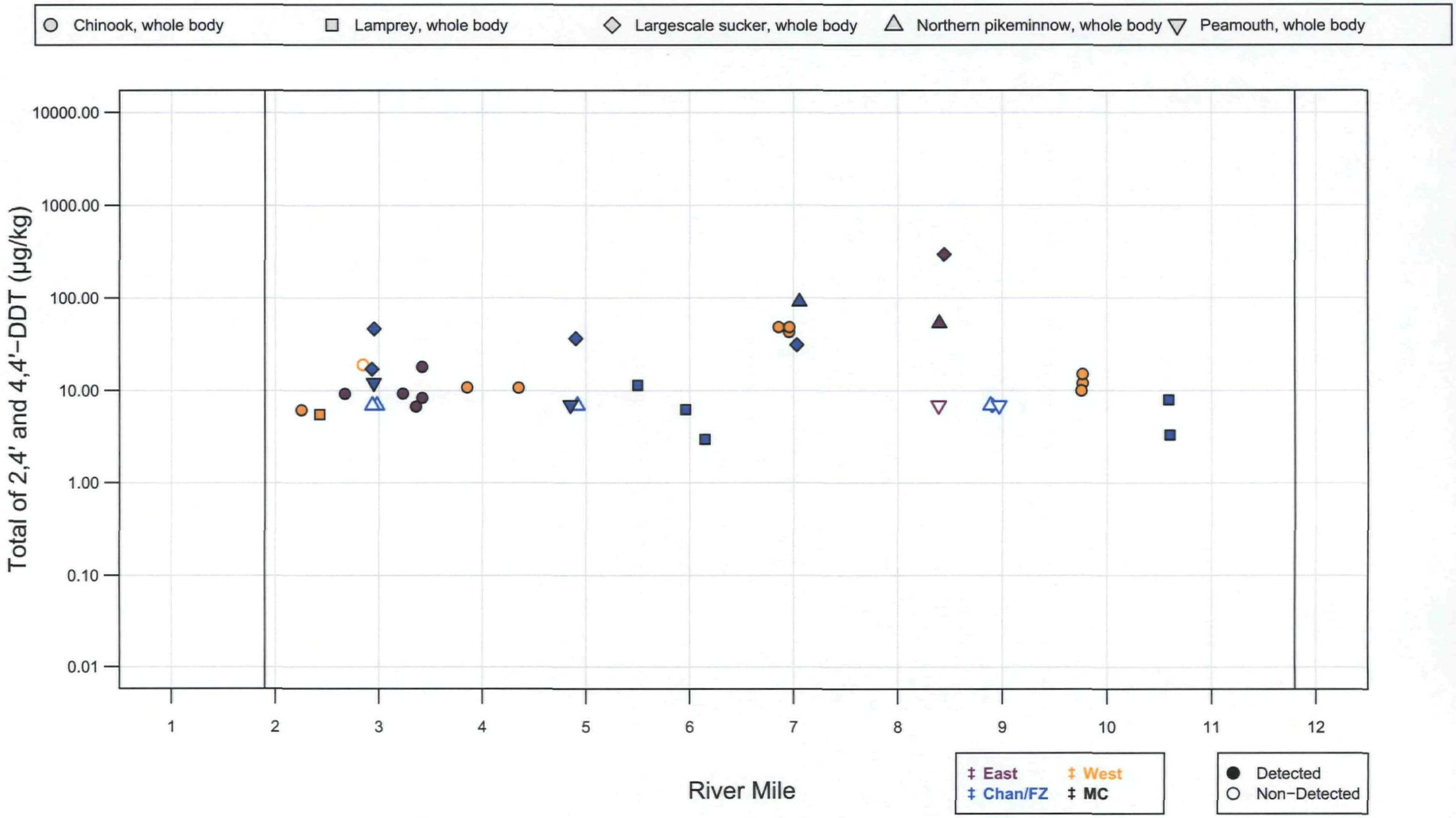

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Figure D5.2-8d

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDT in Tissue Samples by River Mile, RM 0.8-12.2

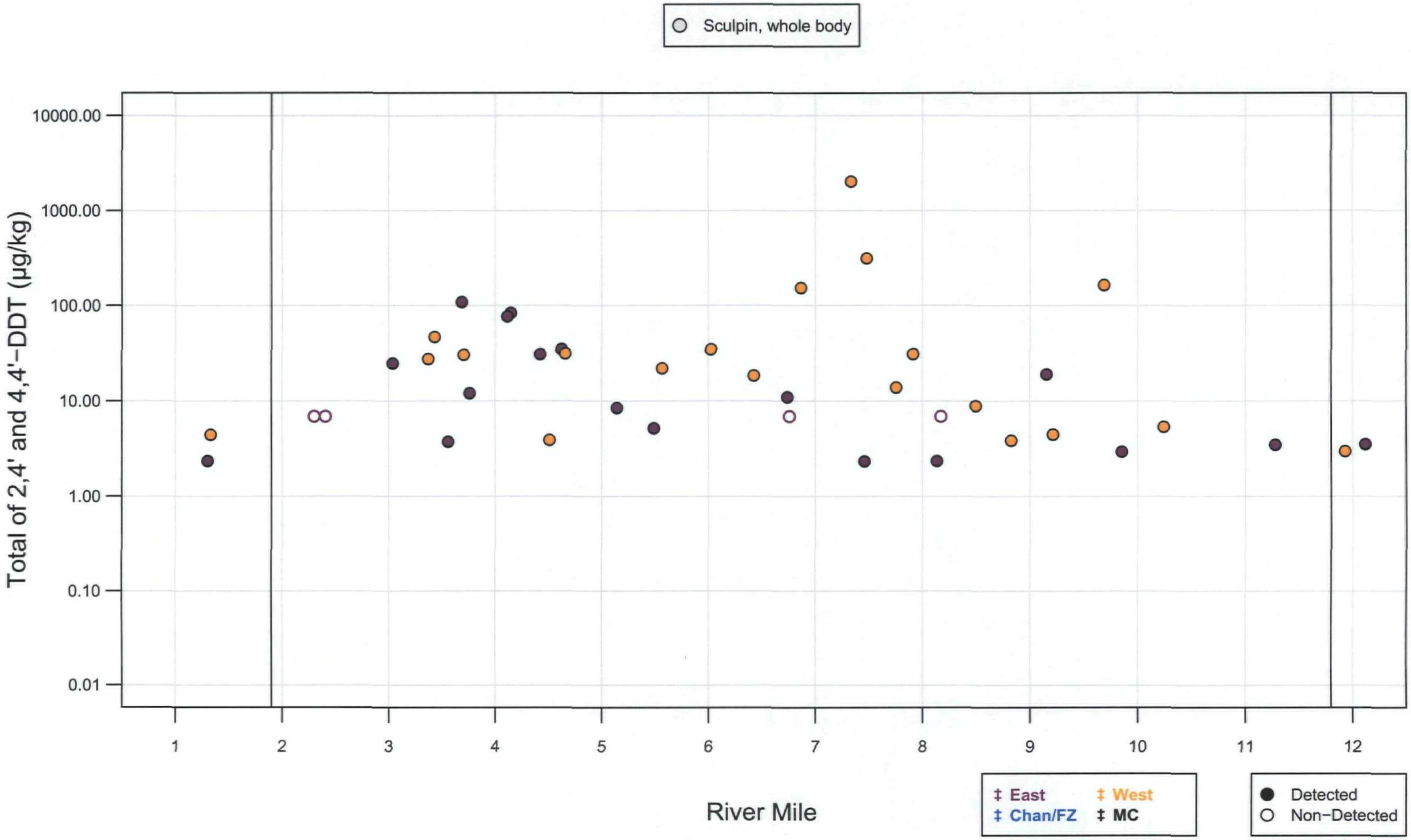

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Figure D5.2-8e

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDT in Tissue Samples by River Mile, RM 0.8-12.2

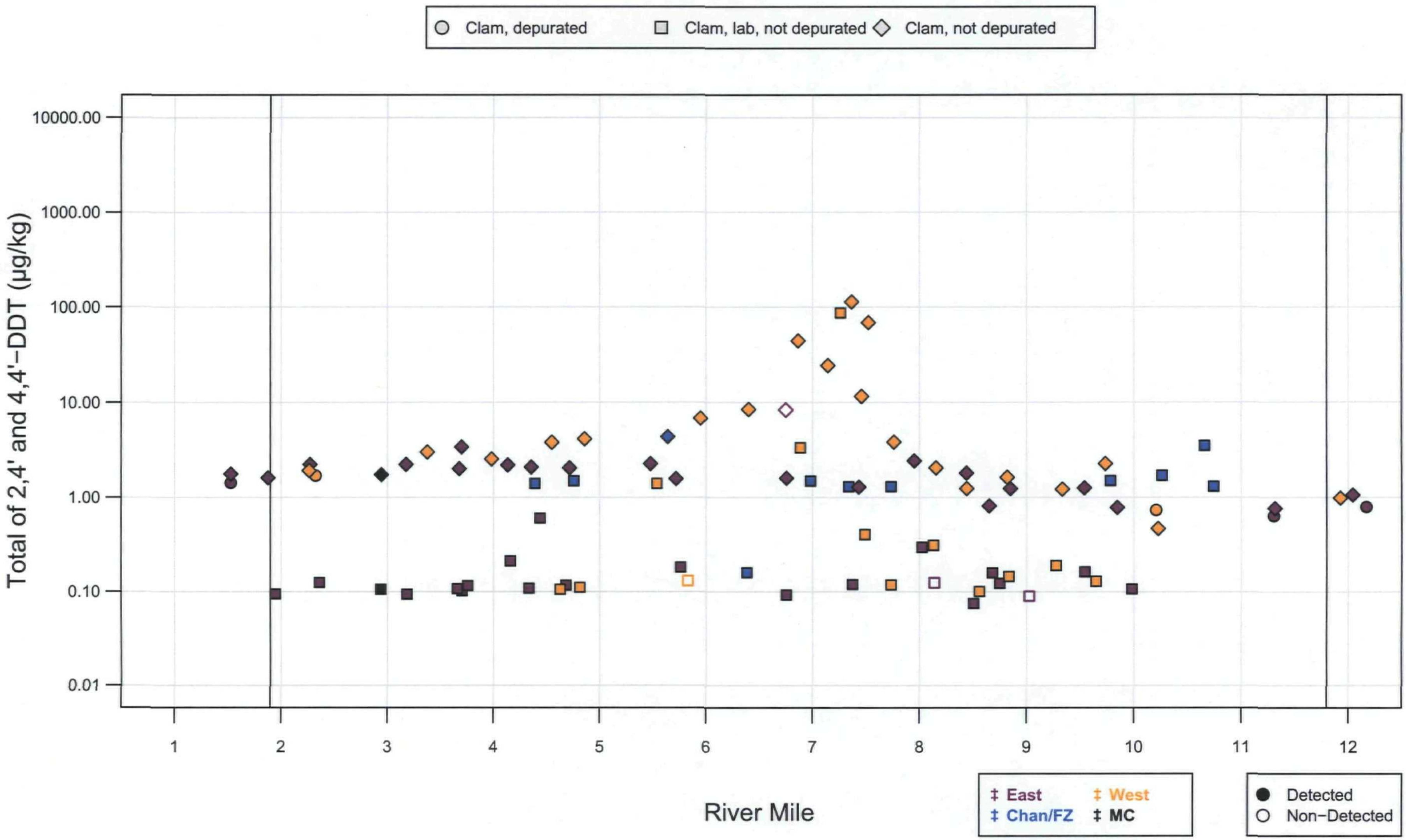

Figure D5.2-8f

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDT in Tissue Samples by River Mile, RM 0.8-12.2

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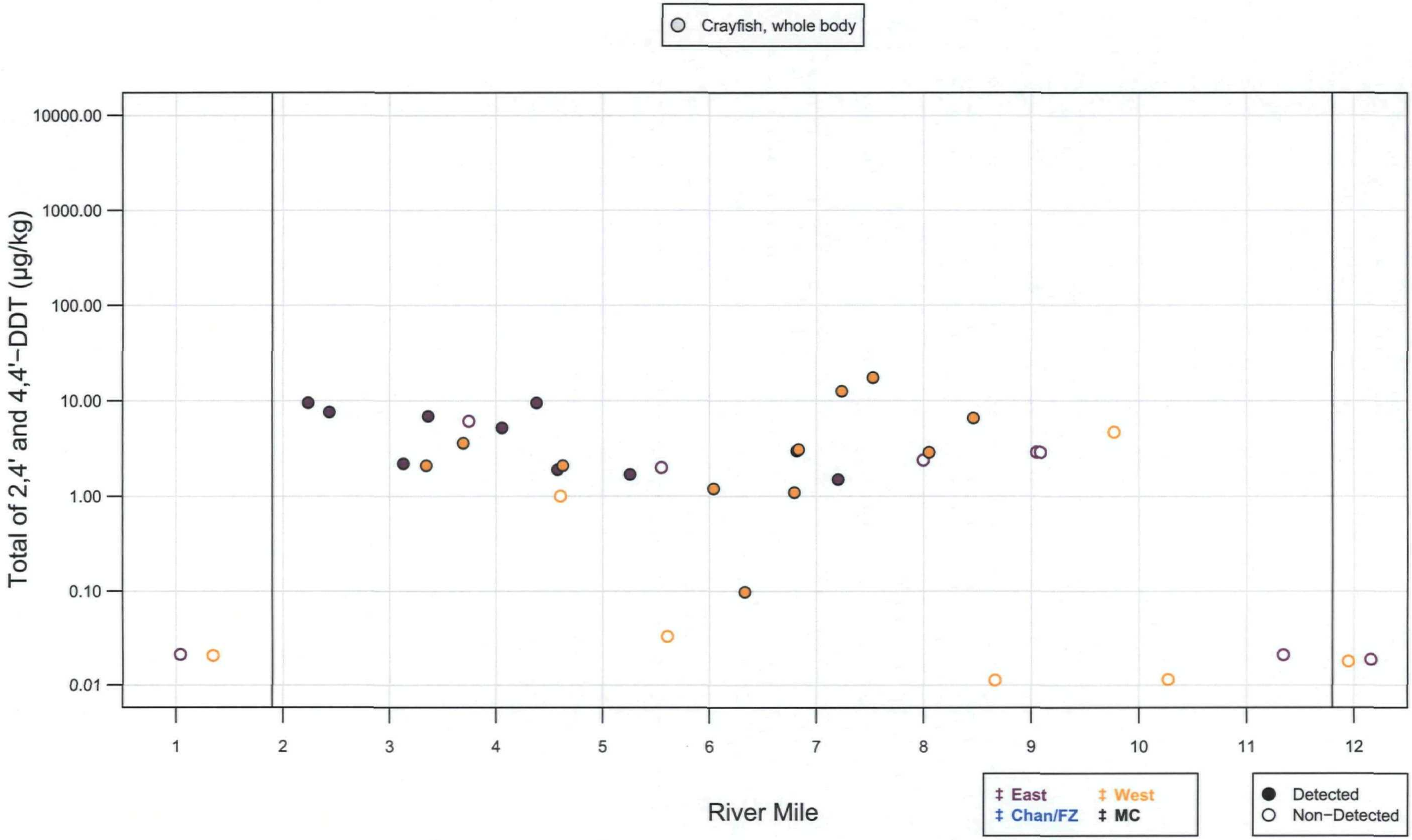

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Figure D5.2-8g
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDT in Tissue Samples by River Mile, RM 0.8-12.2

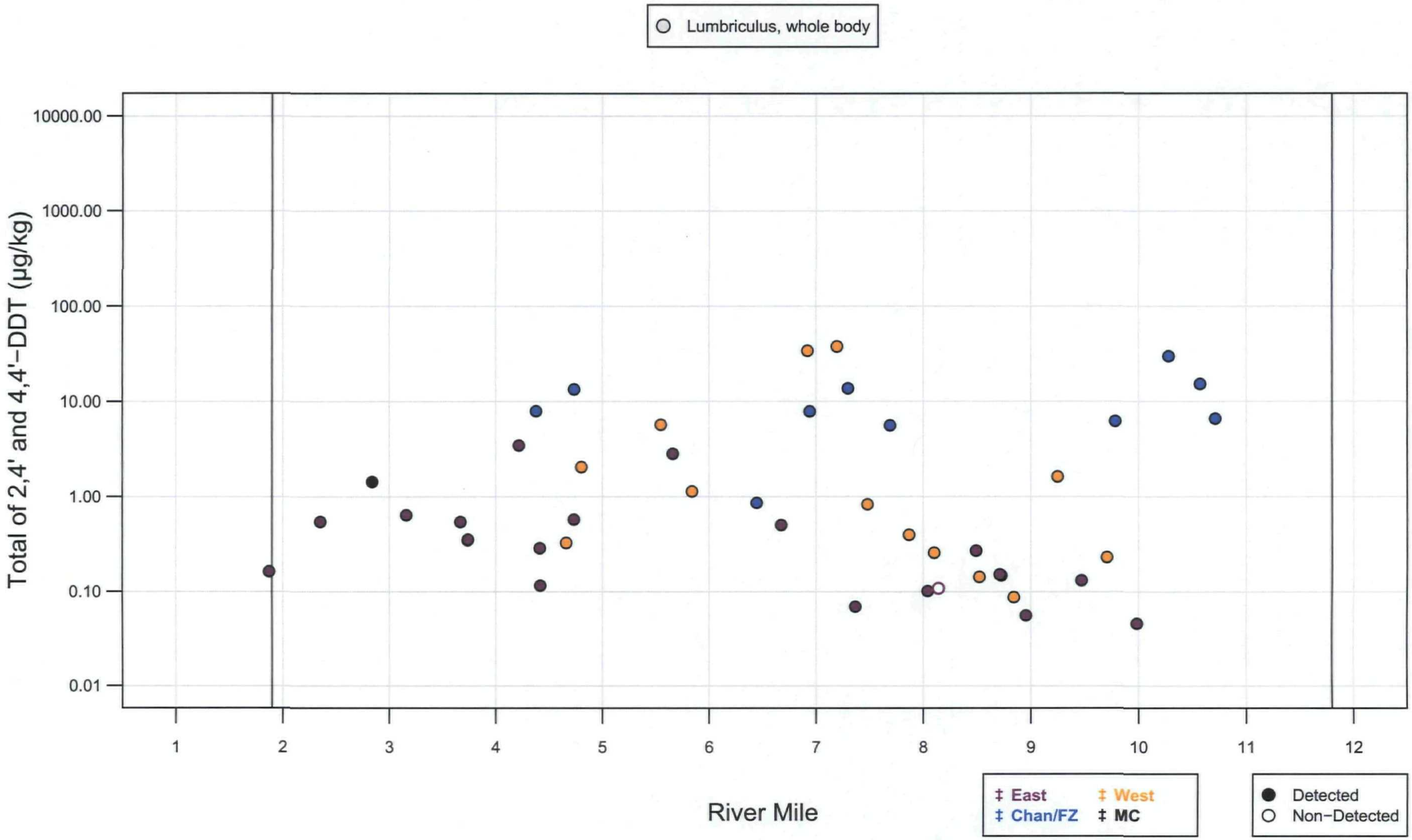

Figure D5.2−8h

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'−DDT in
Tissue Samples by River Mile, RM 0.8−12.2

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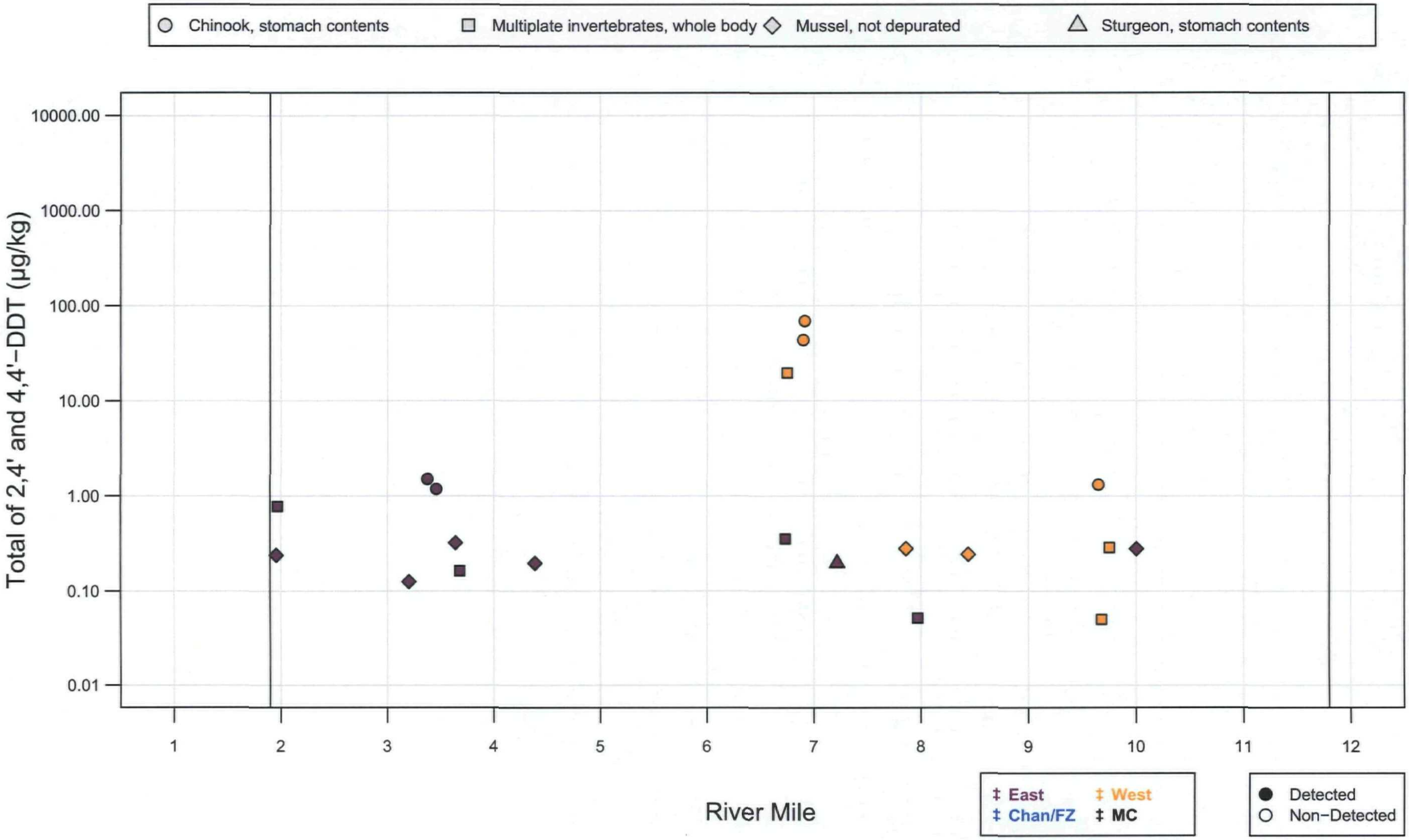

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Figure D5.2−8i

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'−DDT in Tissue Samples by River Mile, RM 0.8−12.2

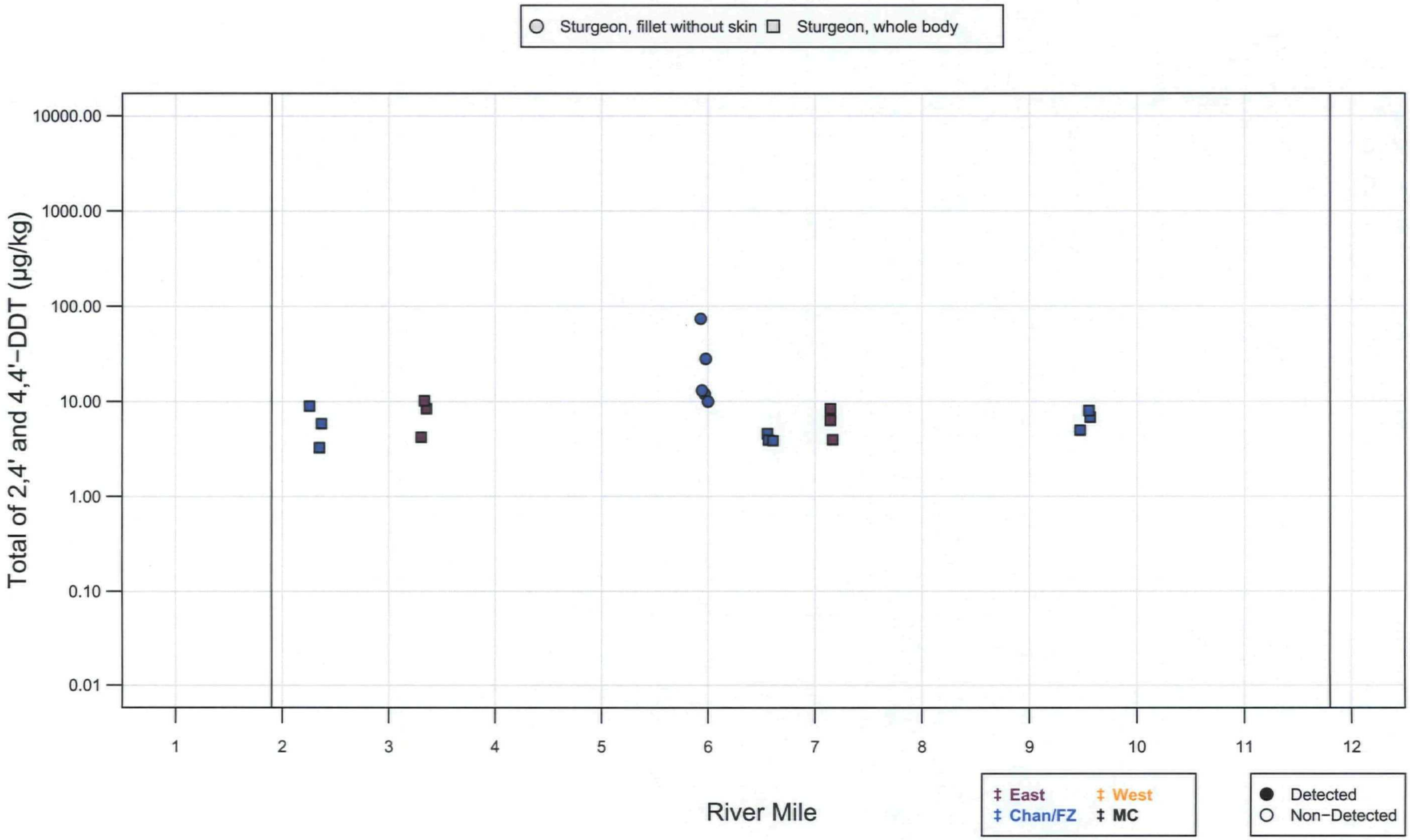

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Figure D5.2-8j

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDT in Tissue Samples by River Mile, RM 0.8-12.2

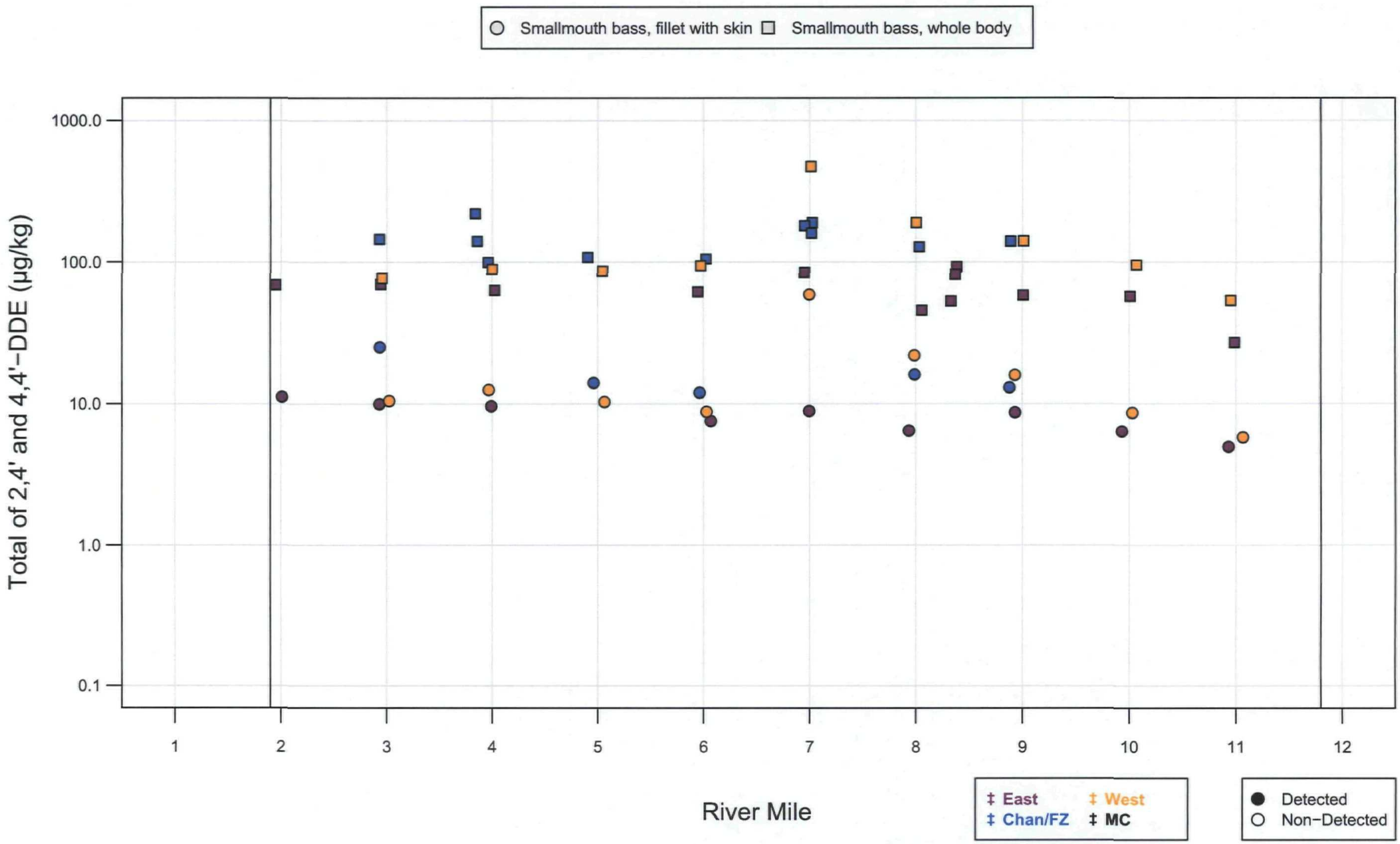

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Figure D5.2-9a

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDE in Tissue Samples by River Mile, RM 0.8-12.2

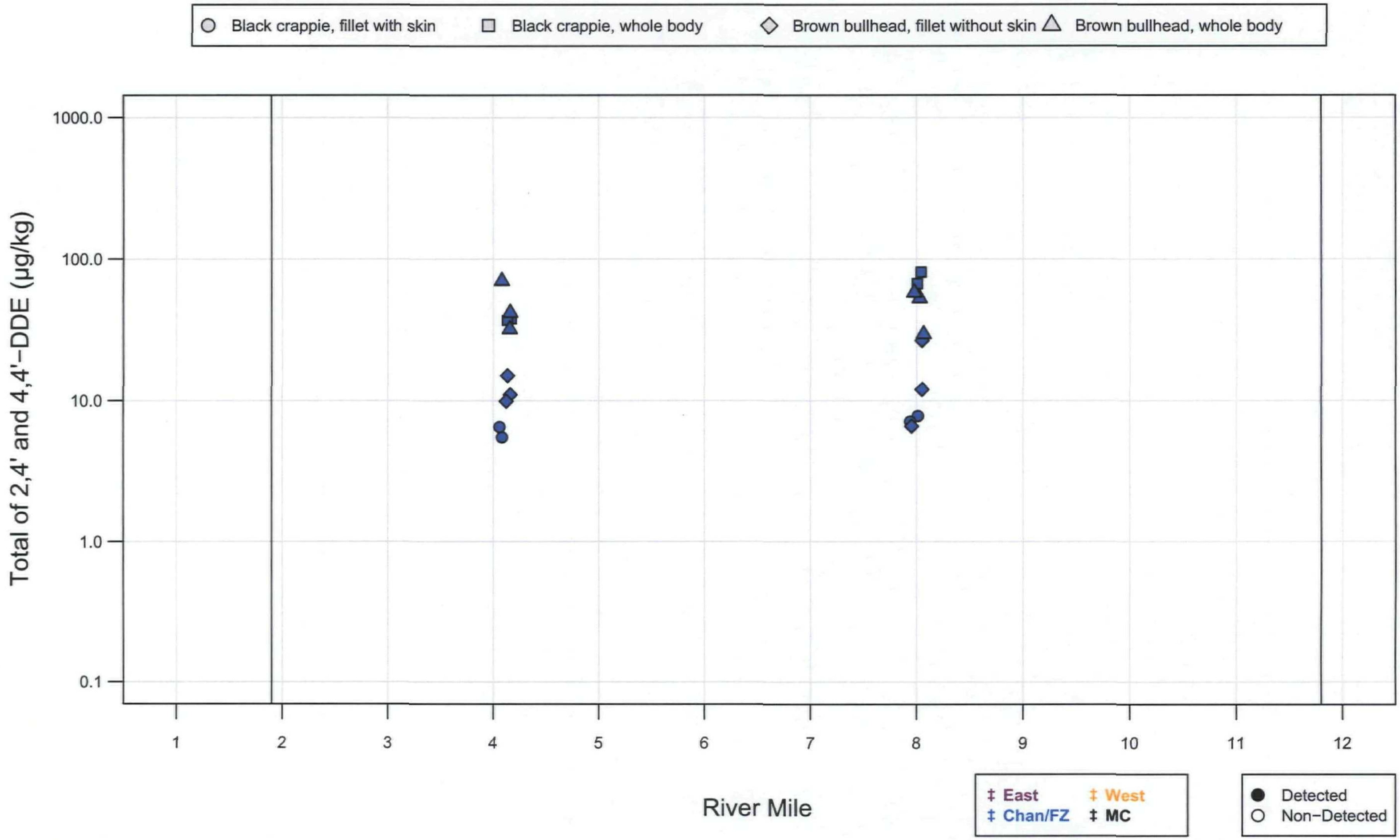

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Figure D5.2-9b

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDE in Tissue Samples by River Mile, RM 0.8-12.2

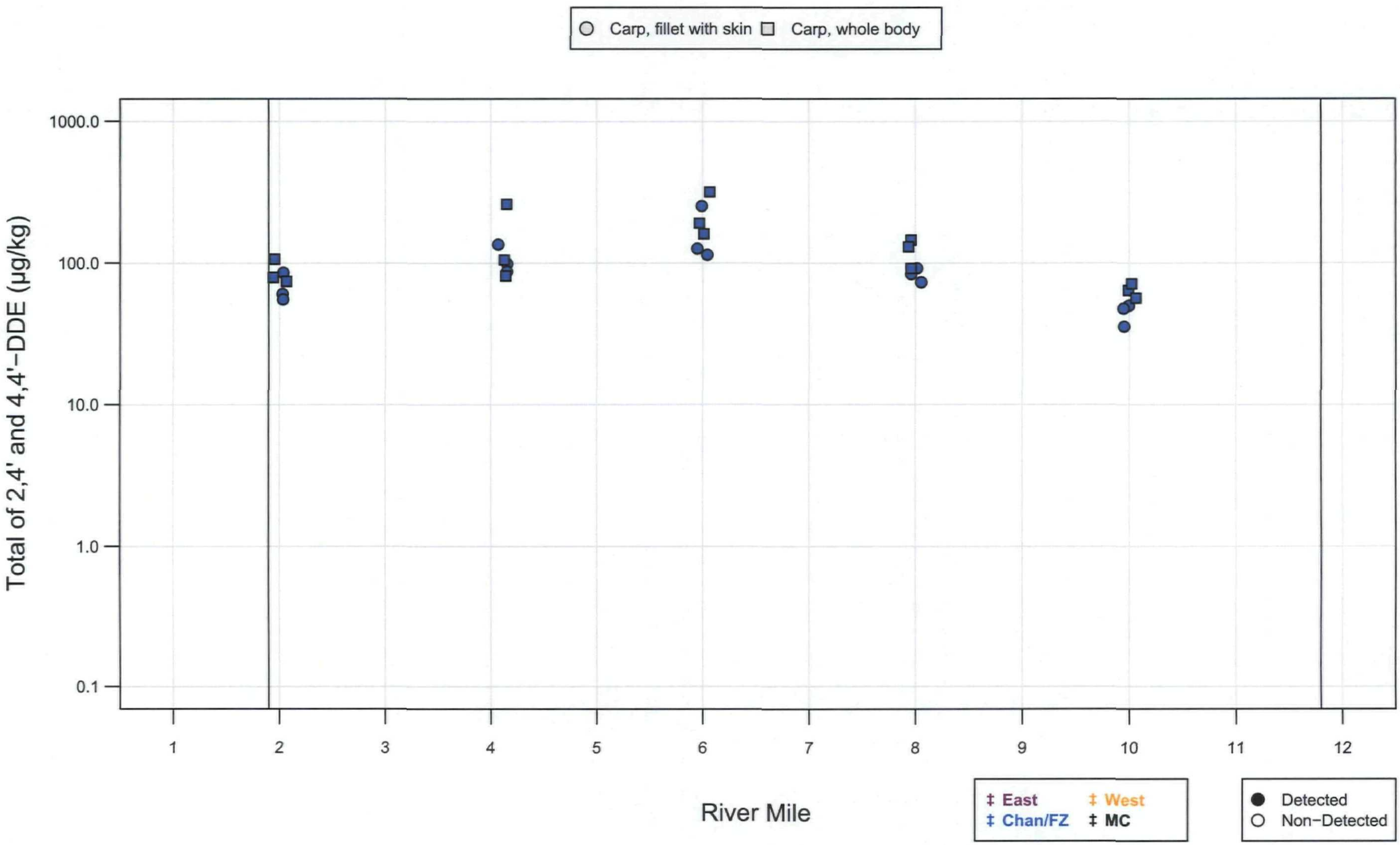

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Figure D5.2−9c

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'−DDE in Tissue Samples by River Mile, RM 0.8−12.2

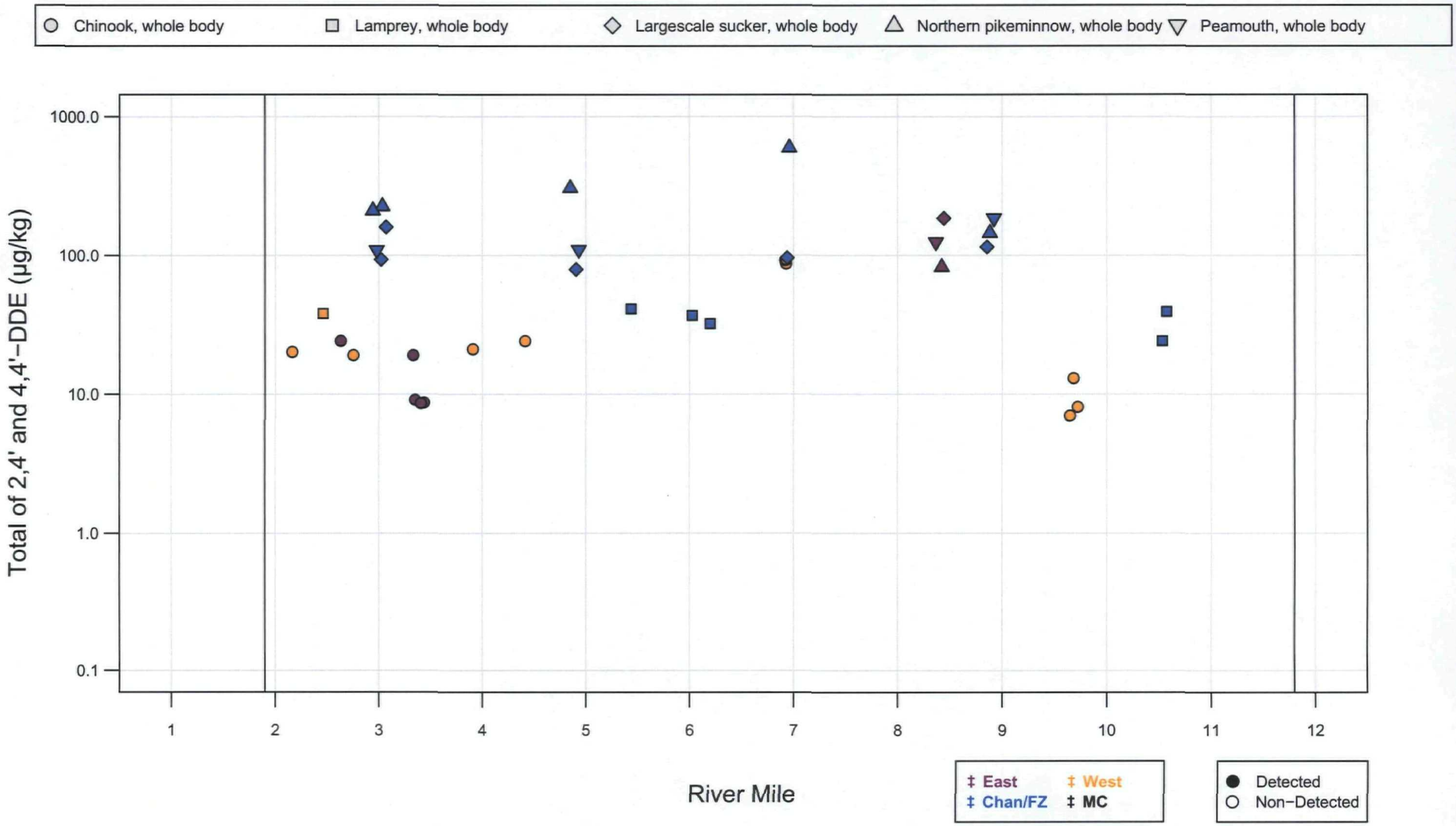

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Figure D5.2-9d

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDE in Tissue Samples by River Mile, RM 0.8-12.2

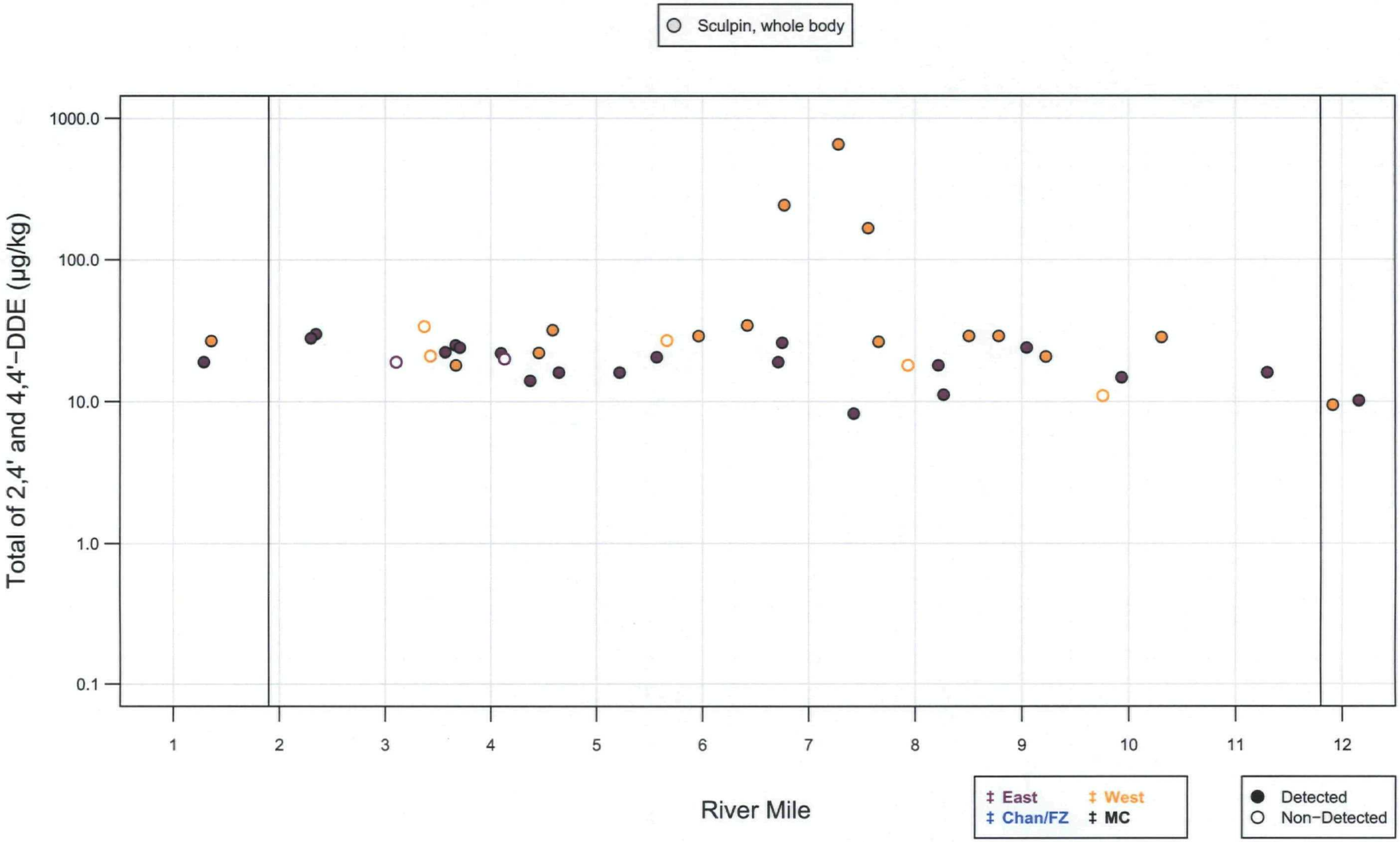

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Figure D5.2−9e

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'−DDE in Tissue Samples by River Mile, RM 0.8−12.2

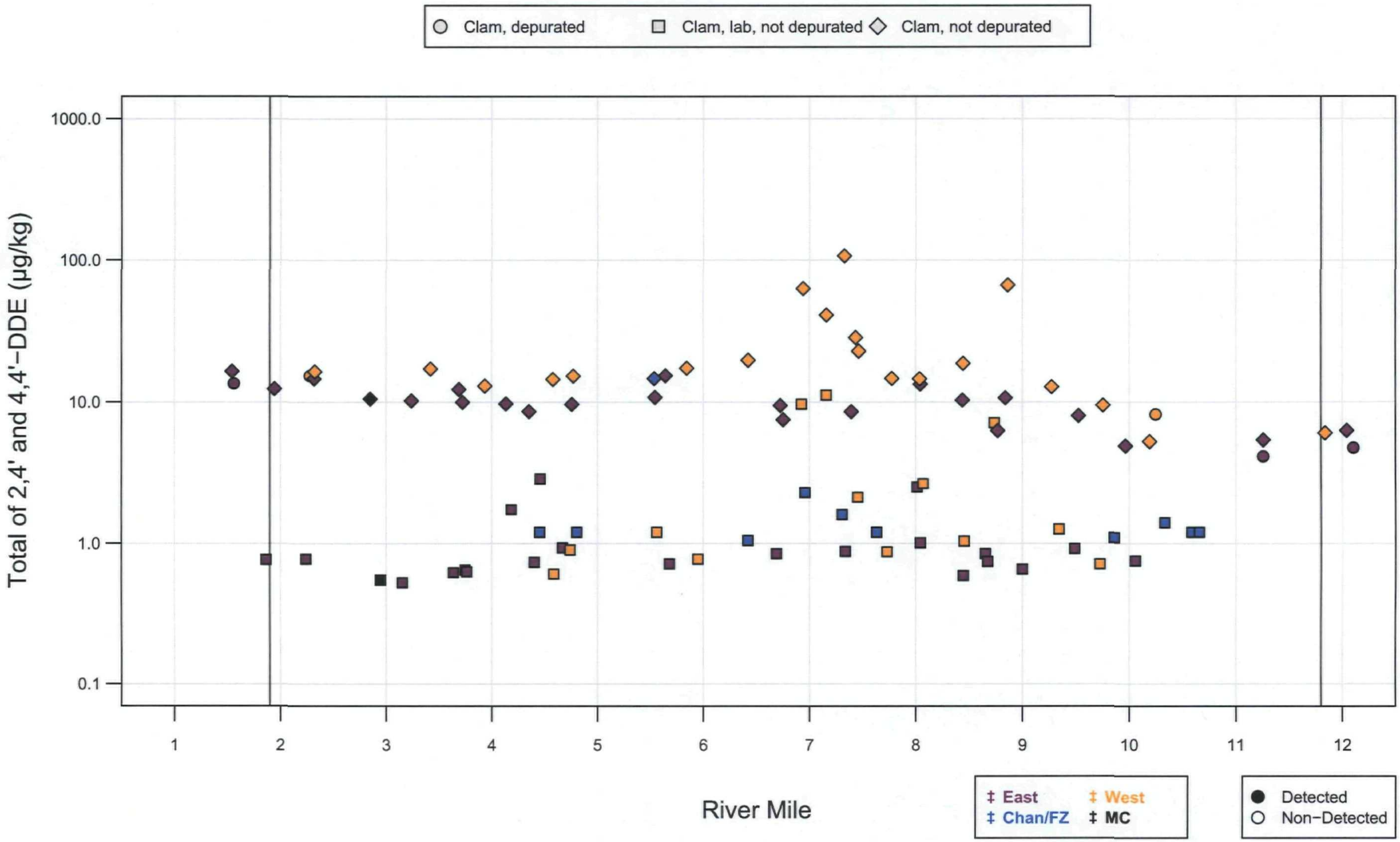

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Figure D5.2-9f
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDE in Tissue Samples by River Mile, RM 0.8-12.2

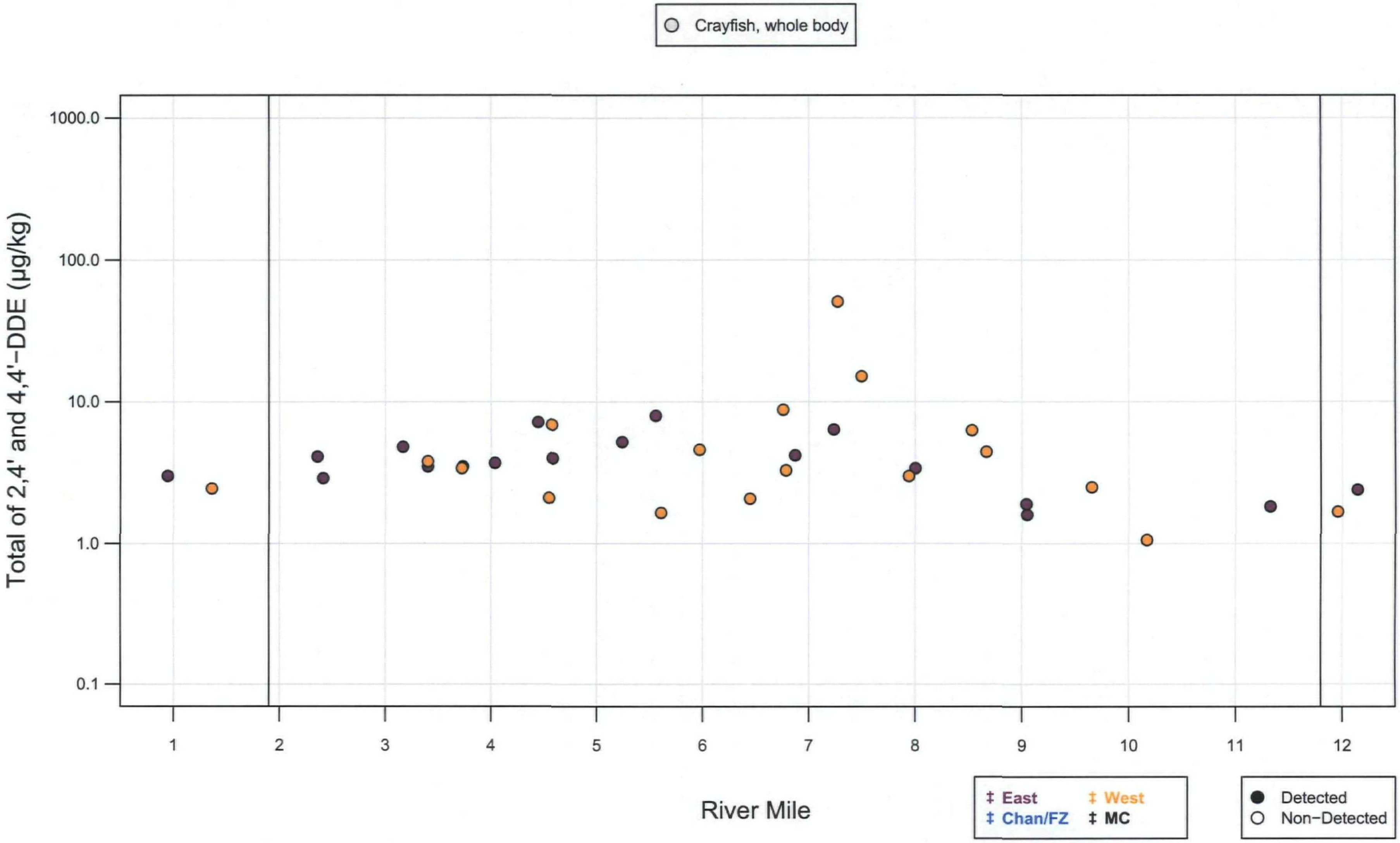

Figure D5.2-9g

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDE in Tissue Samples by River Mile, RM 0.8-12.2

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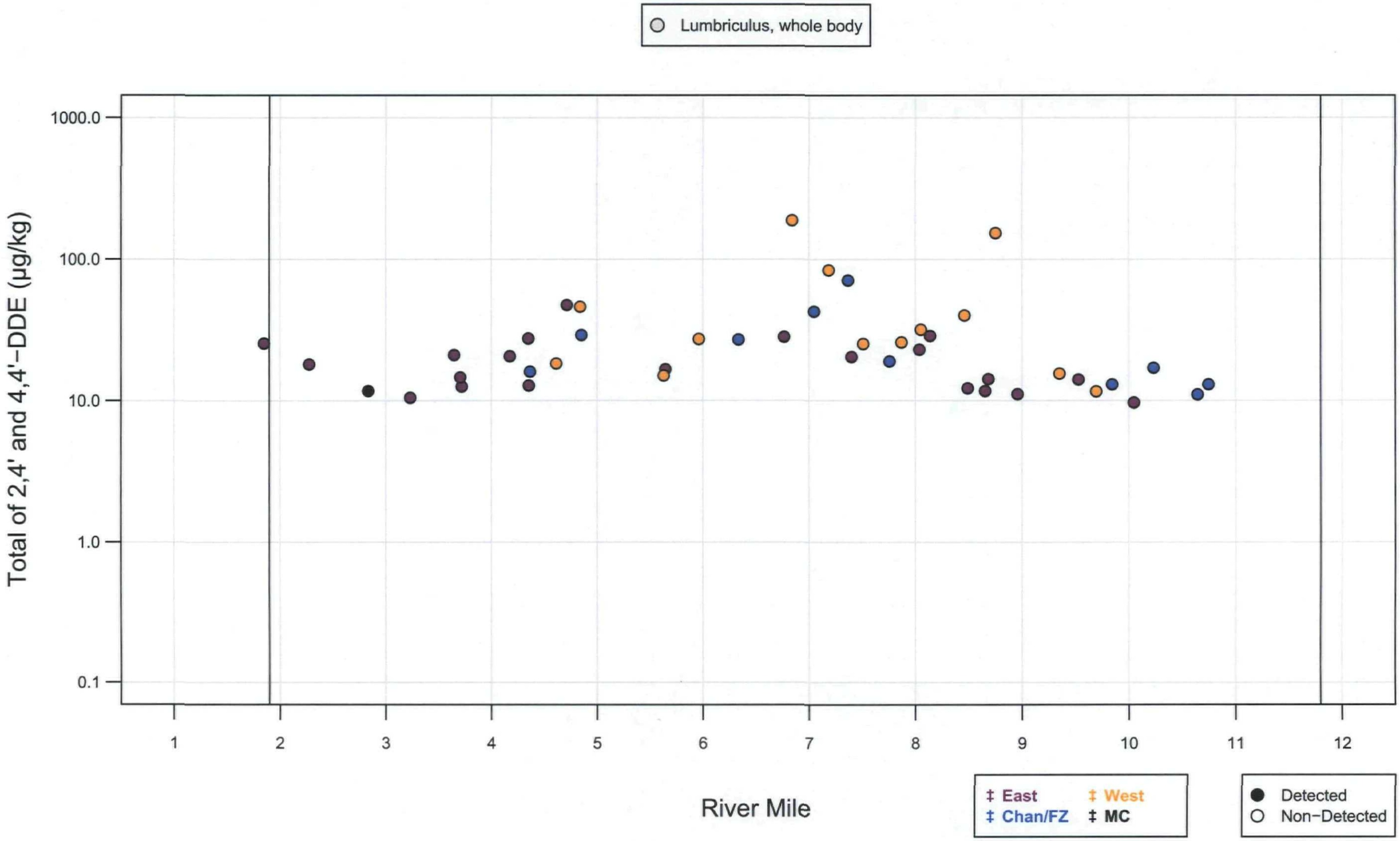

Figure D5.2-9h

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDE in Tissue Samples by River Mile, RM 0.8-12.2

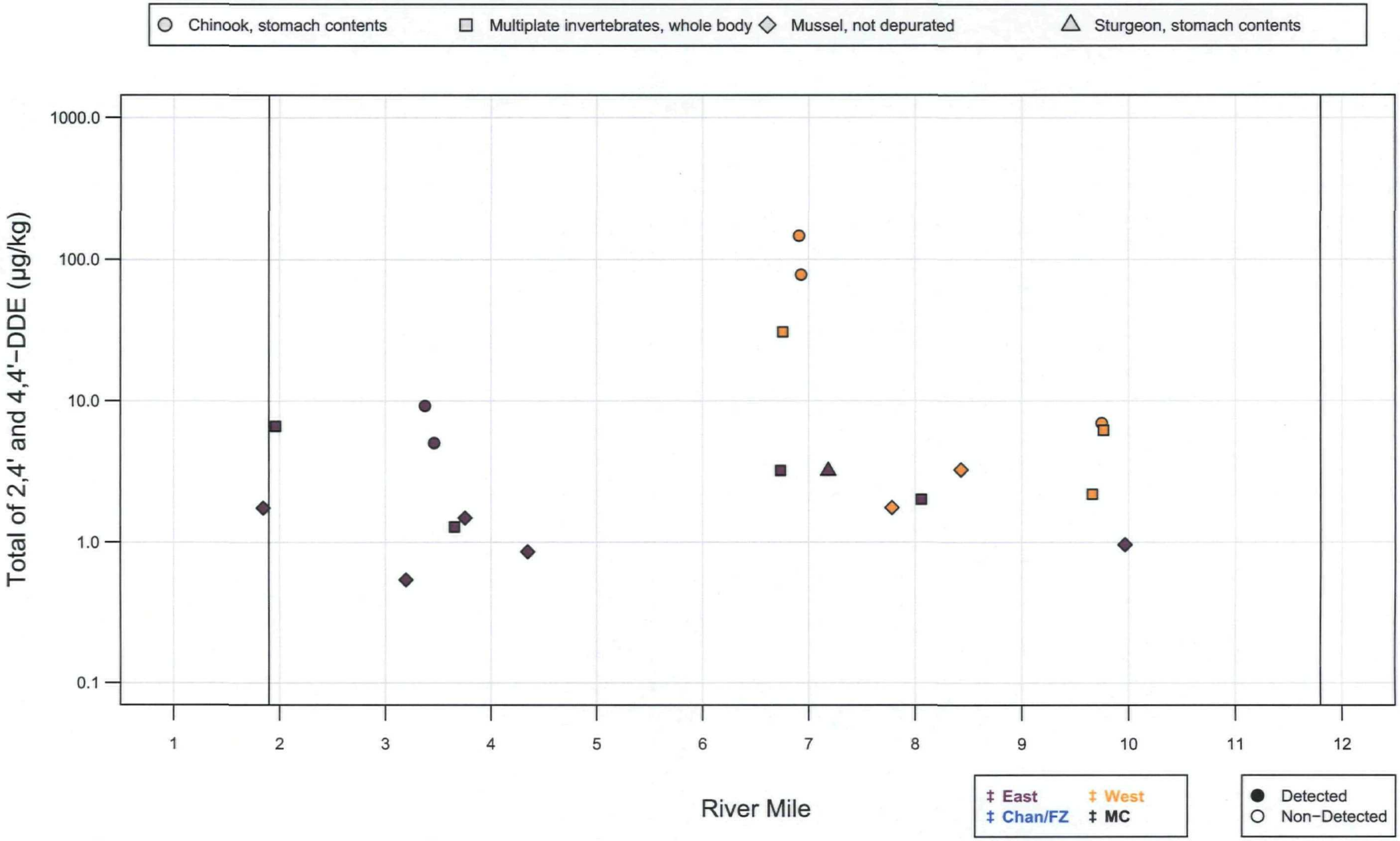

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Figure D5.2-9i

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDE in Tissue Samples by River Mile, RM 0.8-12.2

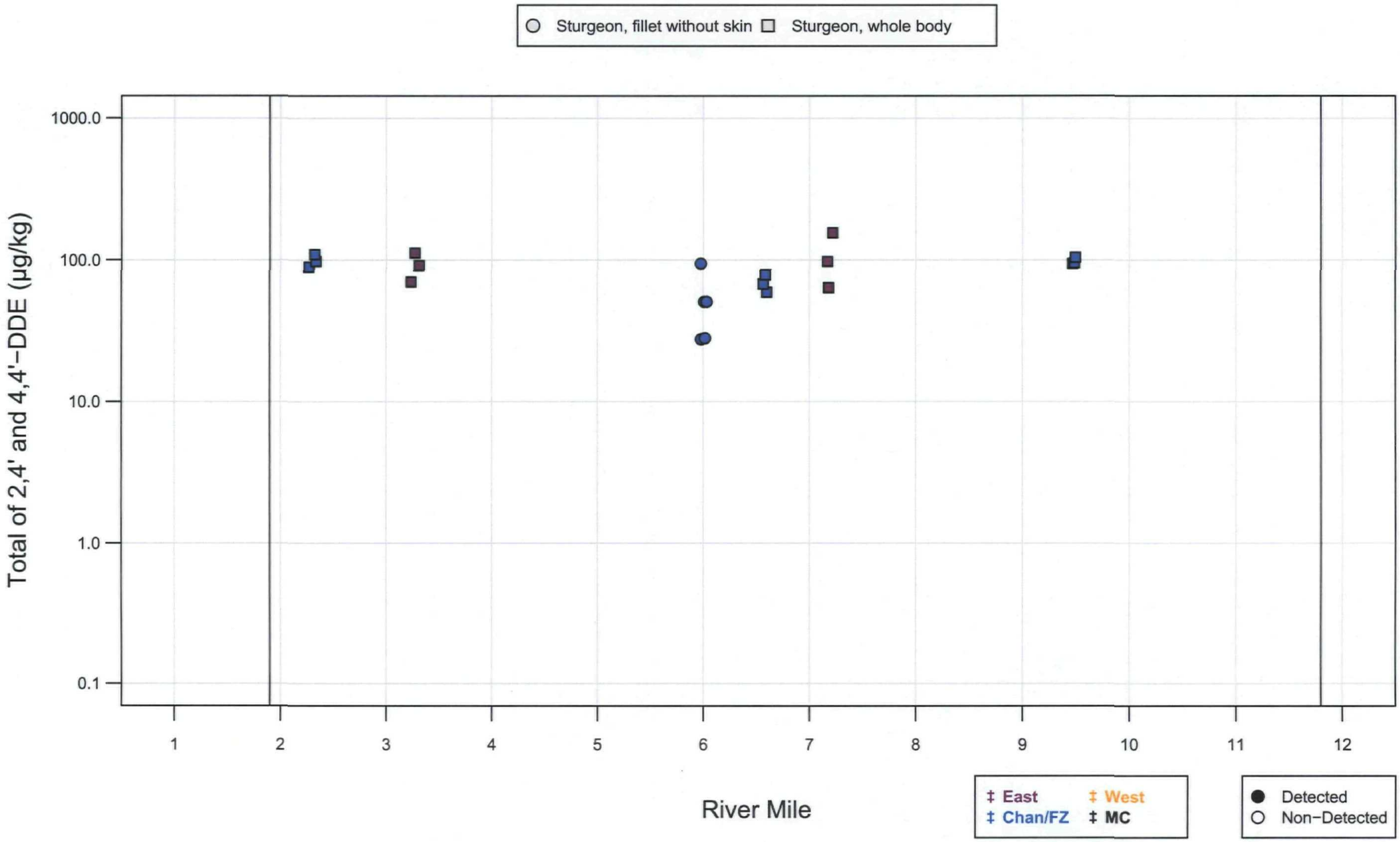

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Figure D5.2-9j
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDE in Tissue Samples by River Mile, RM 0.8-12.2

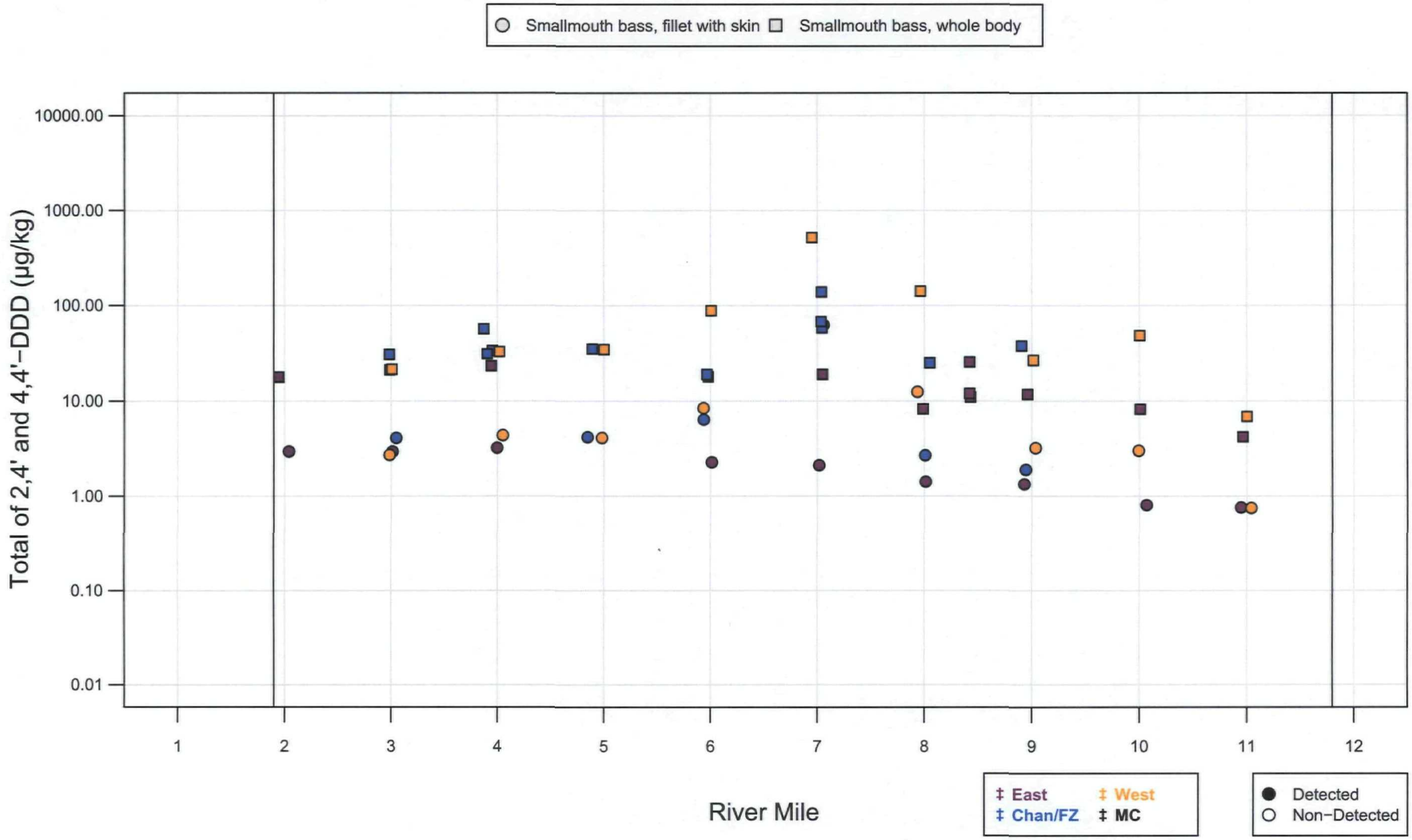

Figure D5.2-10a

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDD in Tissue Samples by River Mile, RM 0.8-12.2

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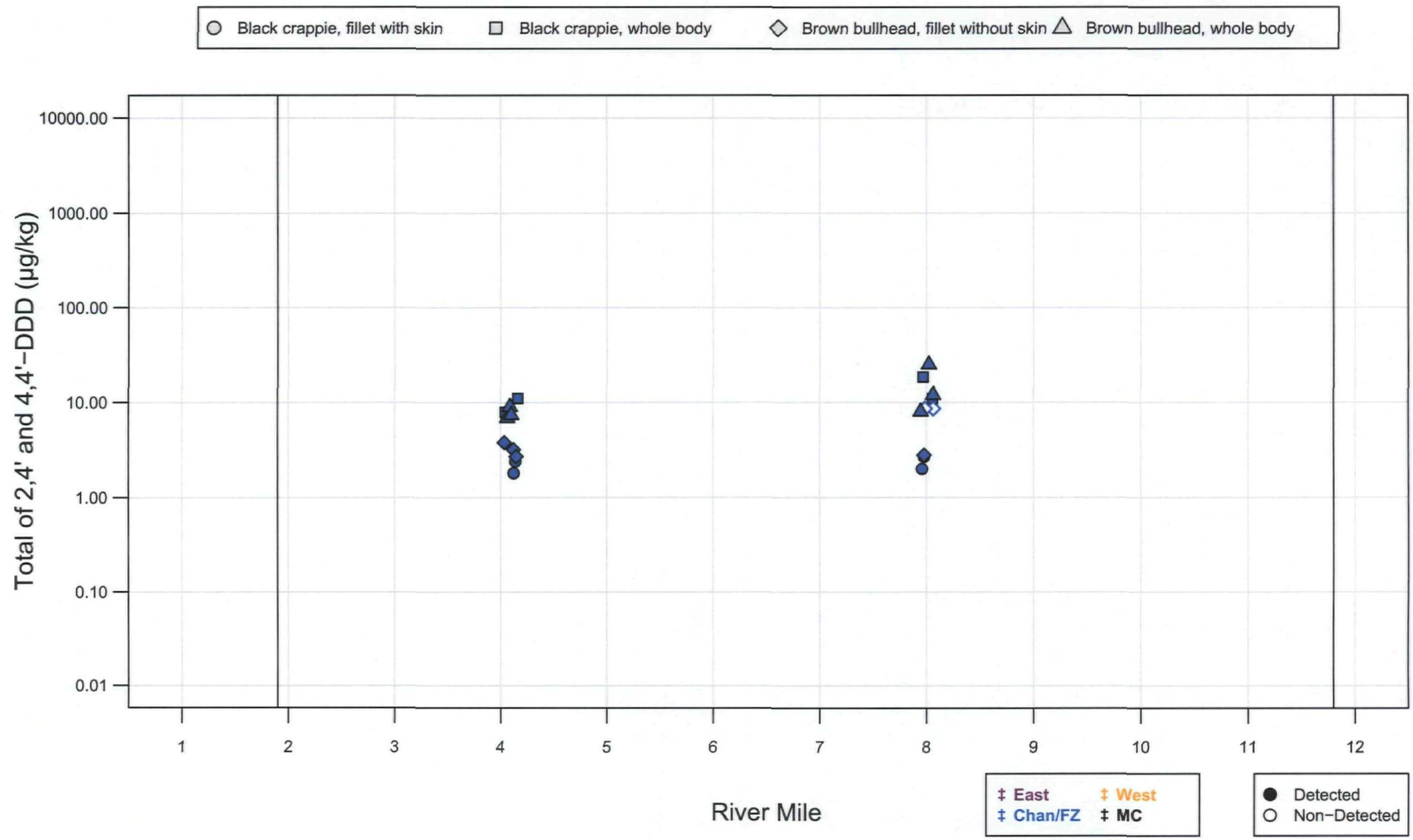

Figure D5.2-10b

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDD in Tissue Samples by River Mile, RM 0.8-12.2

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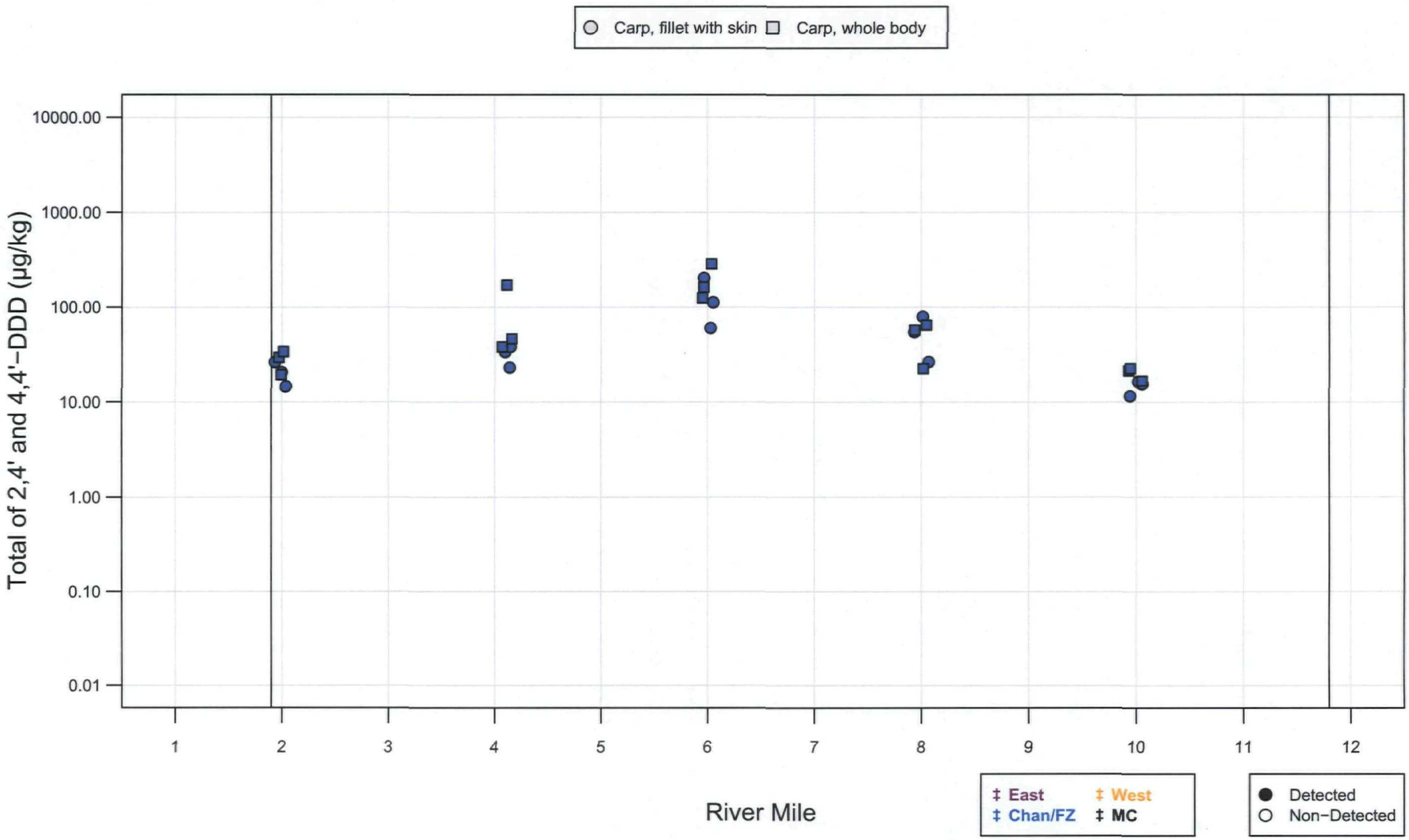

Figure D5.2-10c

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDD in Tissue Samples by River Mile, RM 0.8-12.2

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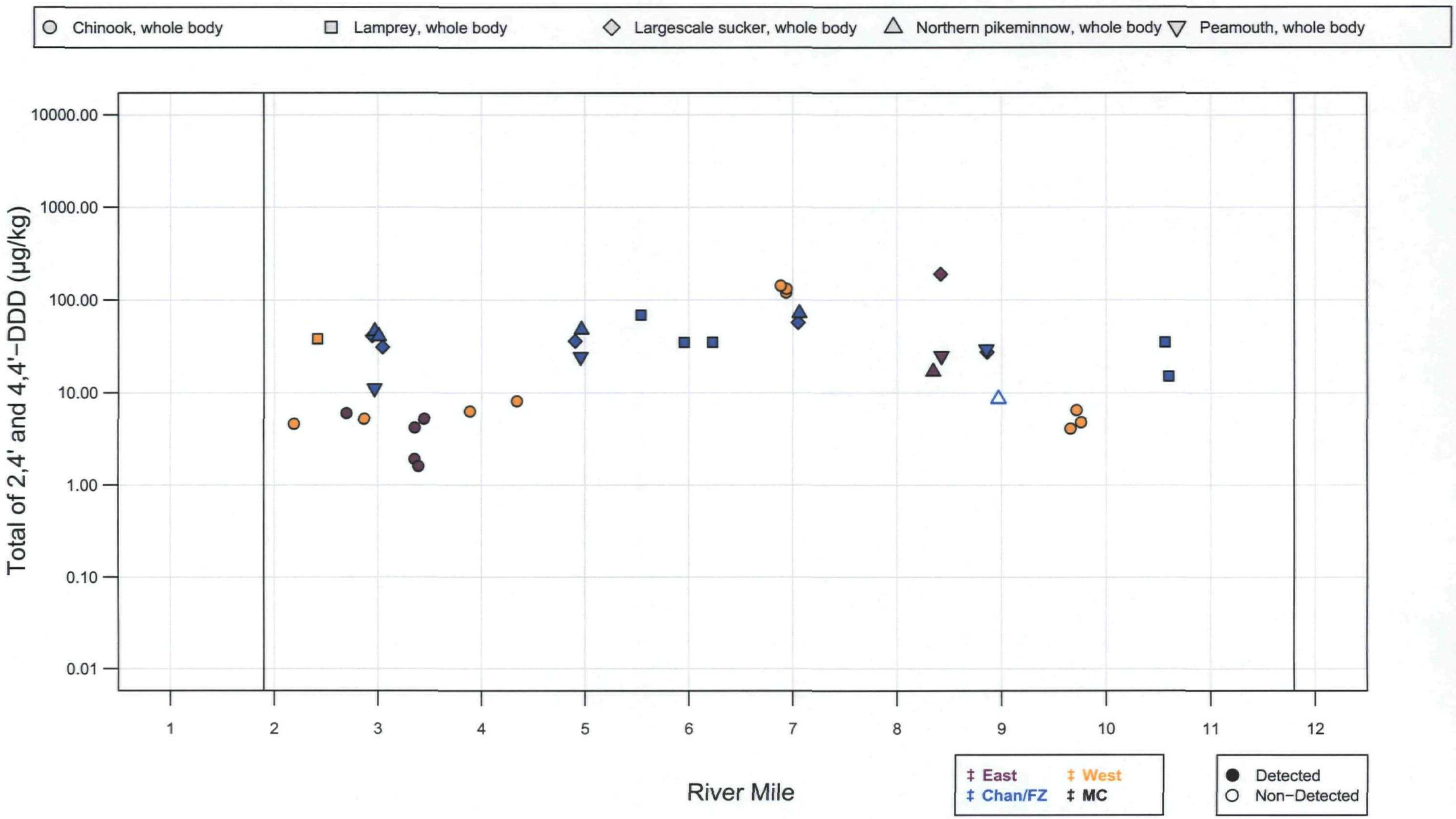

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Figure D5.2-10d
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDD in Tissue Samples by River Mile, RM 0.8-12.2

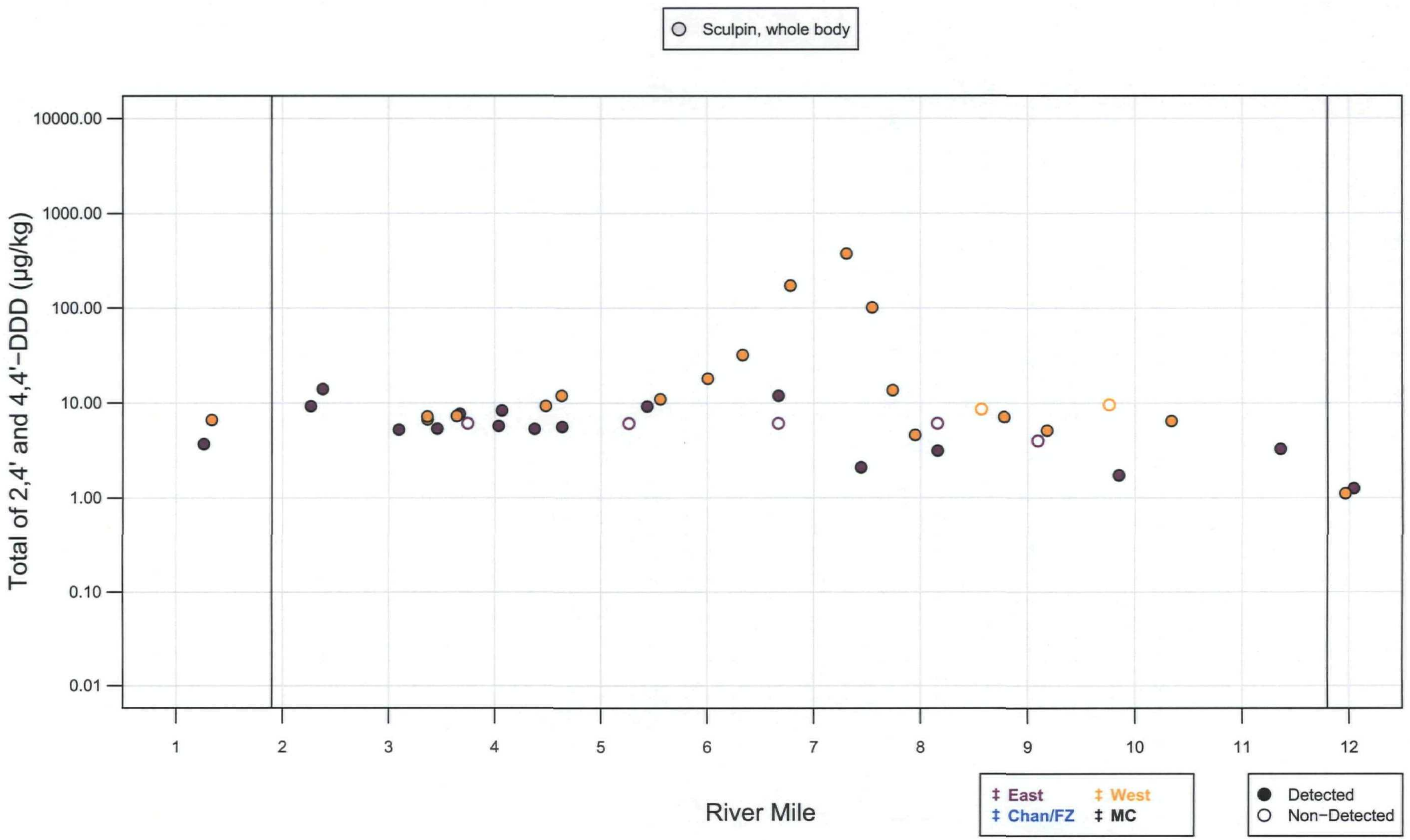

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Figure D5.2-10e

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDD in Tissue Samples by River Mile, RM 0.8-12.2

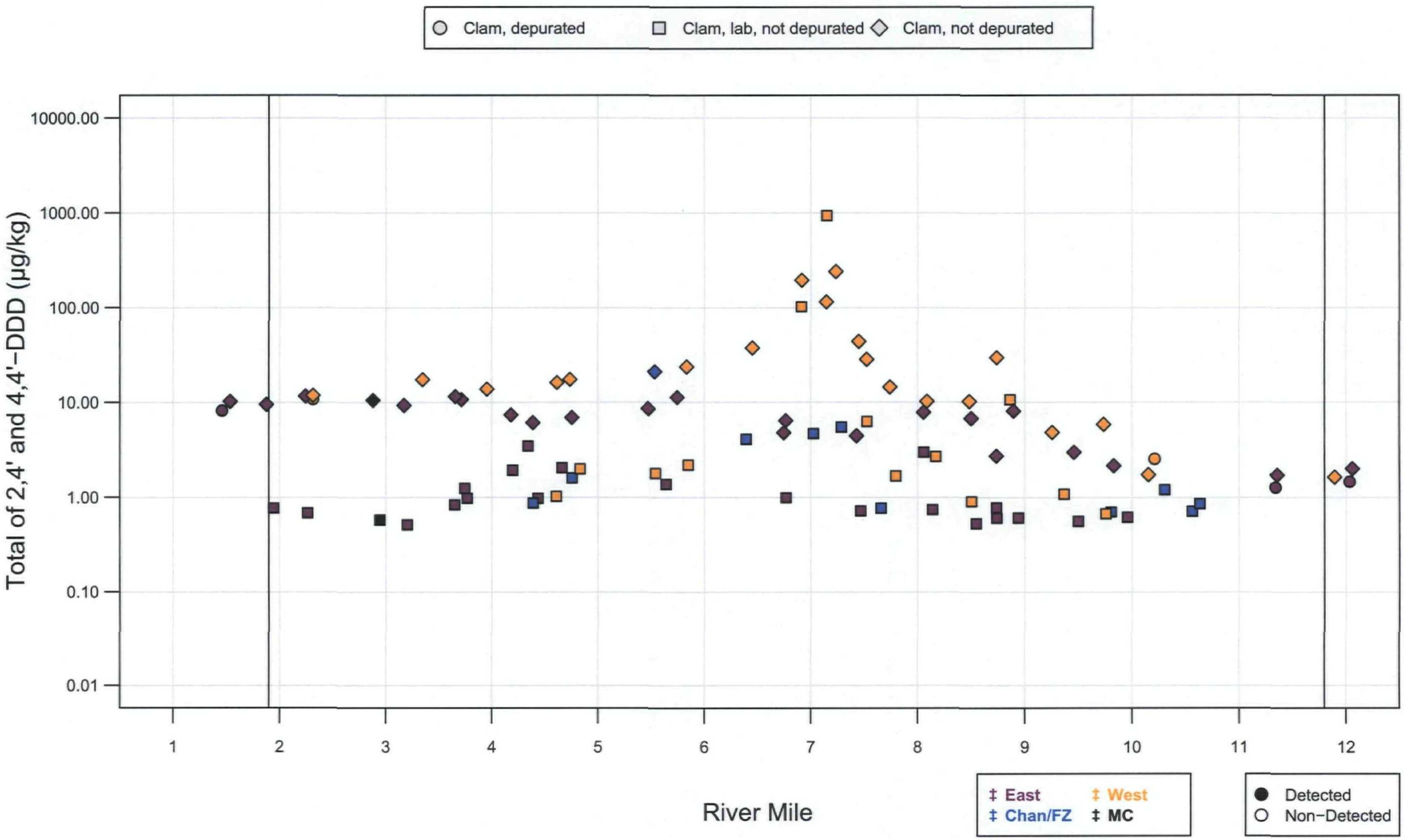

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Figure D5.2-10f
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDD in Tissue Samples by River Mile, RM 0.8-12.2

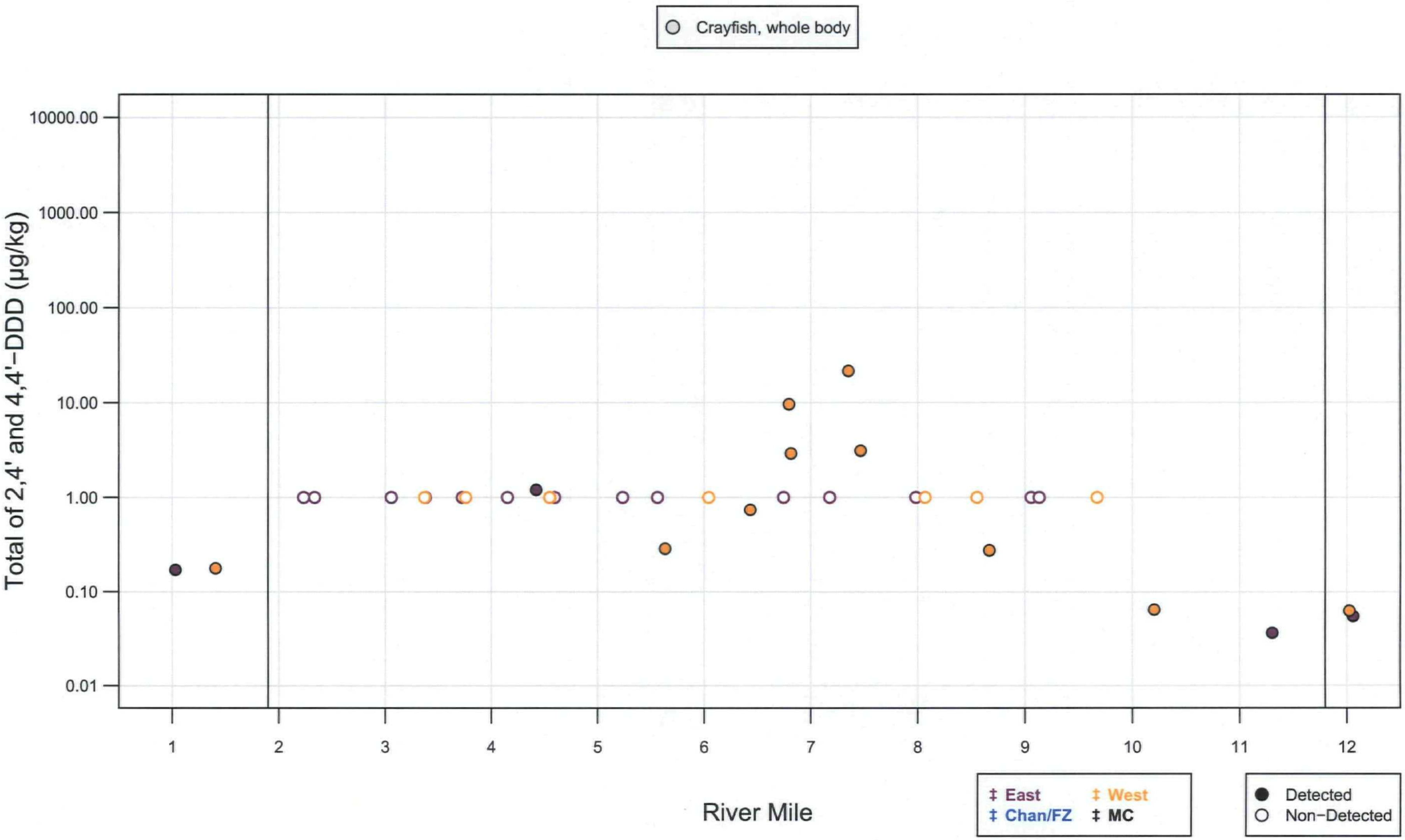

Figure D5.2−10g

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'−DDD in Tissue Samples by River Mile, RM 0.8−12.2

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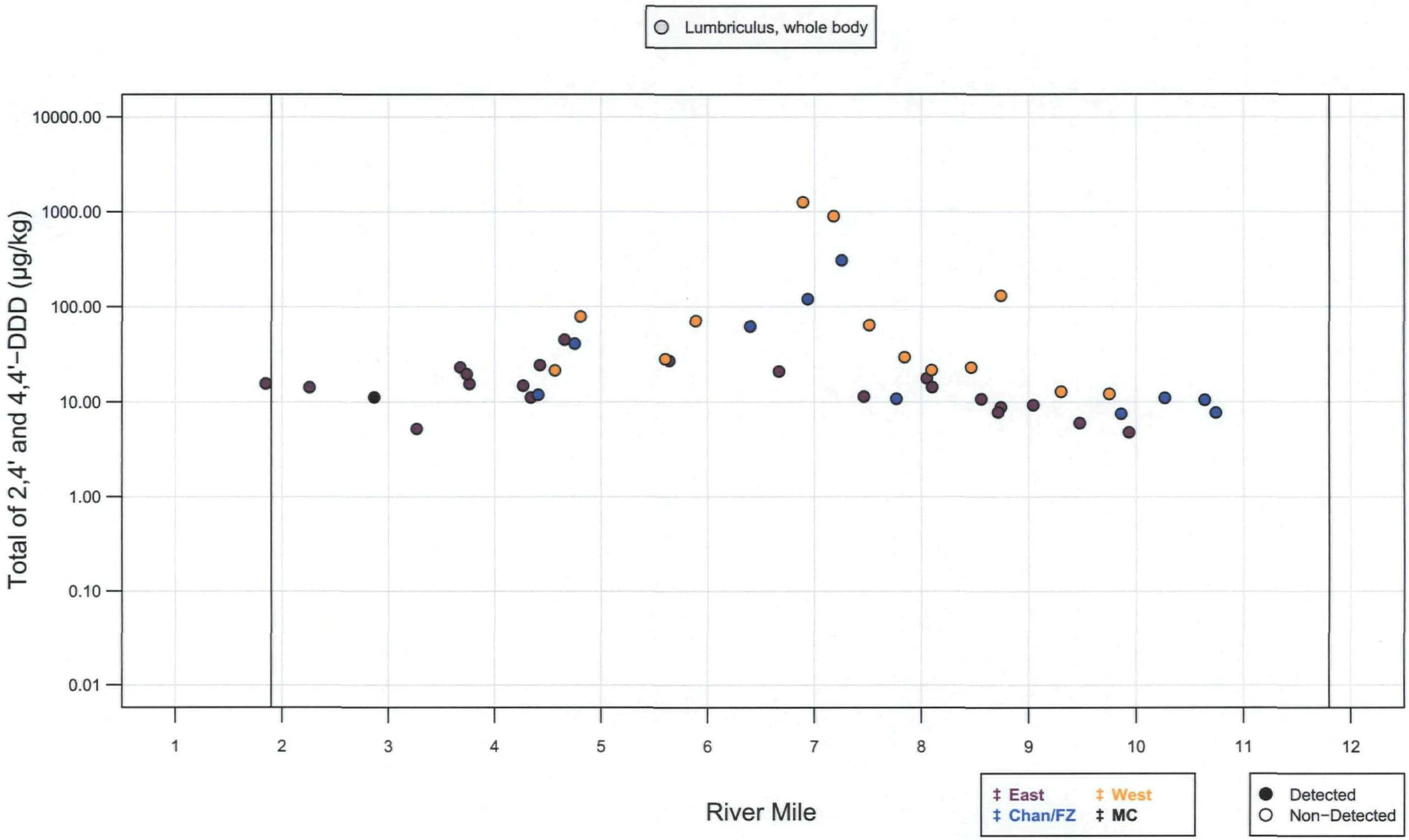

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Figure D5.2-10h

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDD in Tissue Samples by River Mile, RM 0.8-12.2

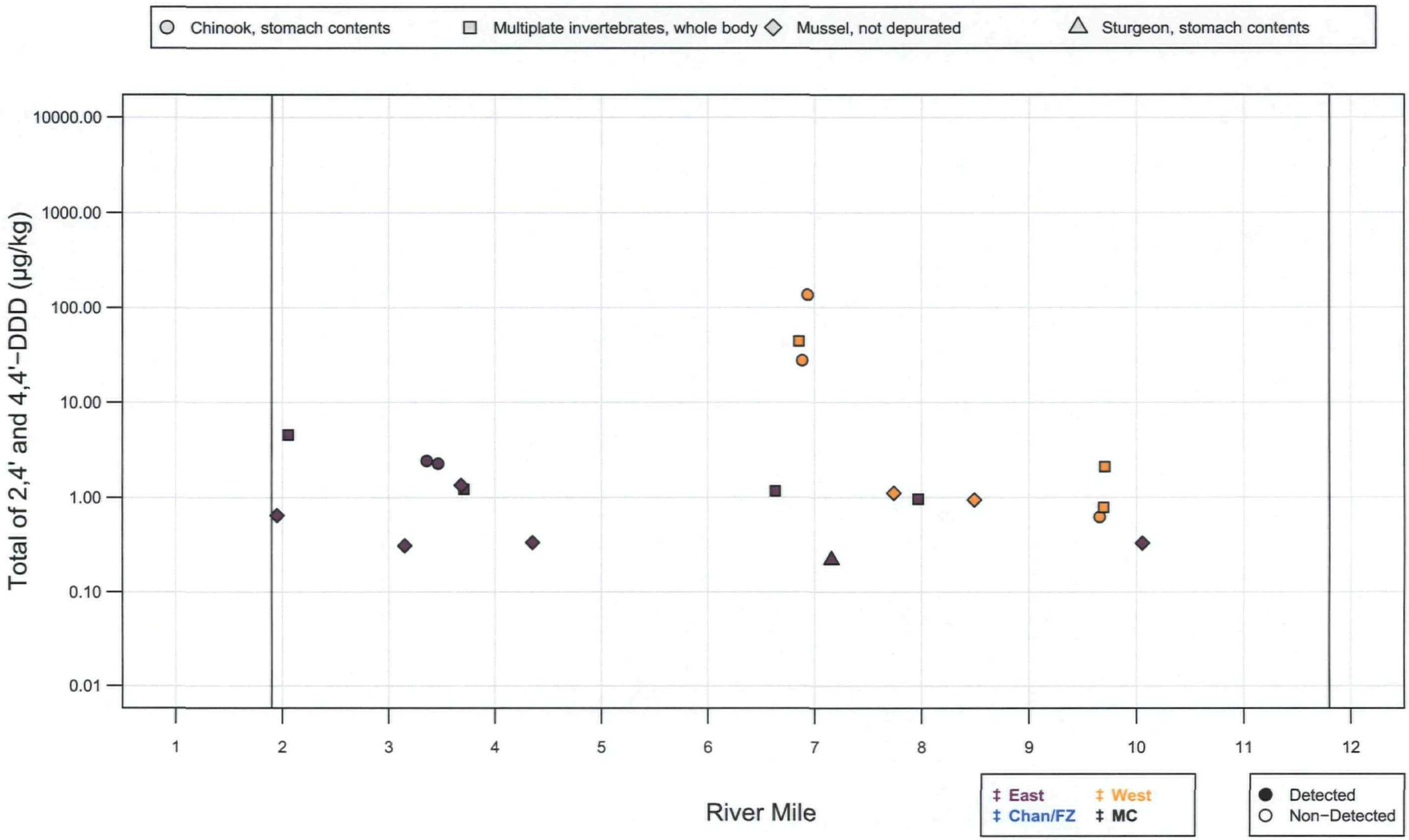

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Figure D5.2-10i

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDD in Tissue Samples by River Mile, RM 0.8-12.2

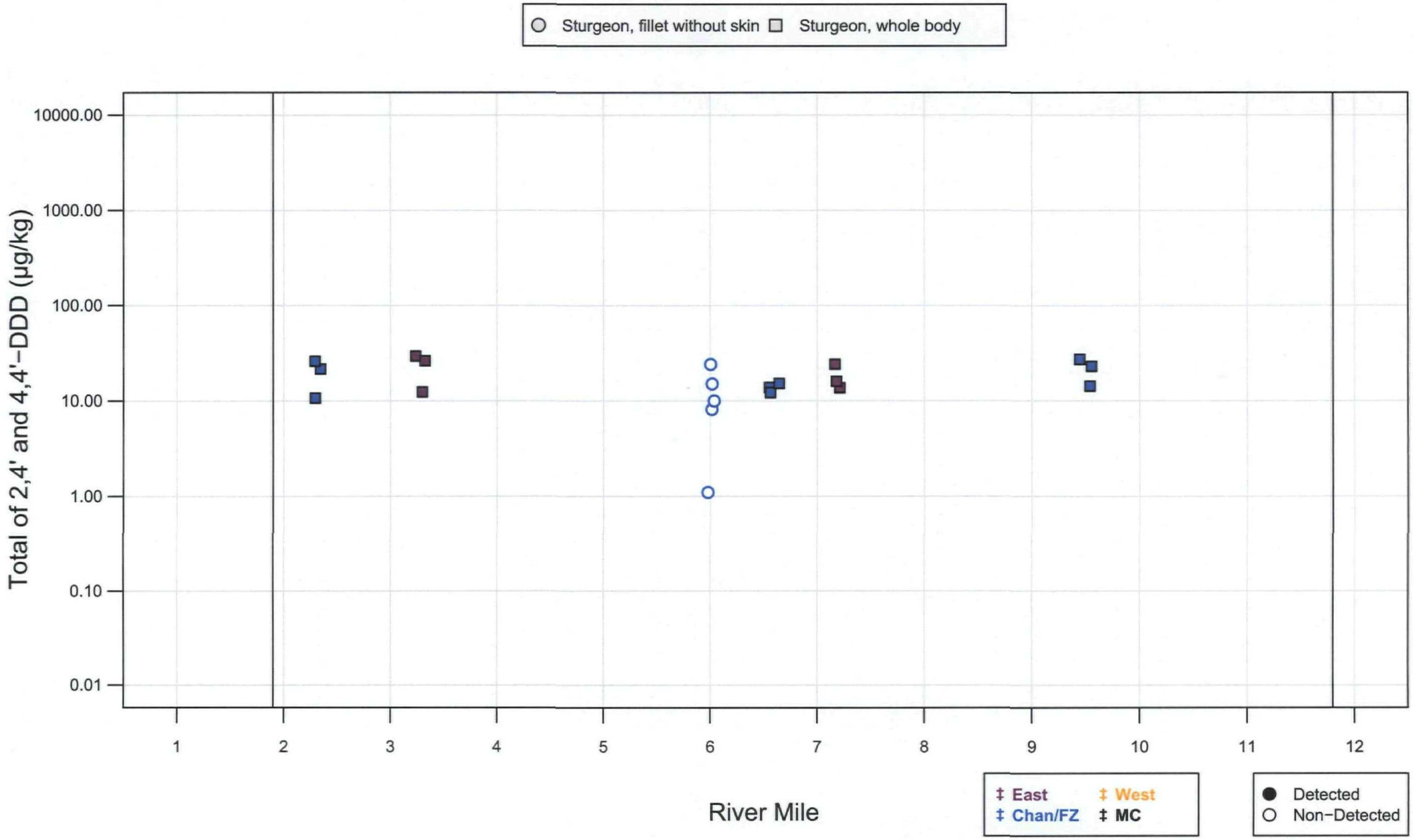

Figure D5.2-10j

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total of 2,4' and 4,4'-DDD in Tissue Samples by River Mile, RM 0.8-12.2

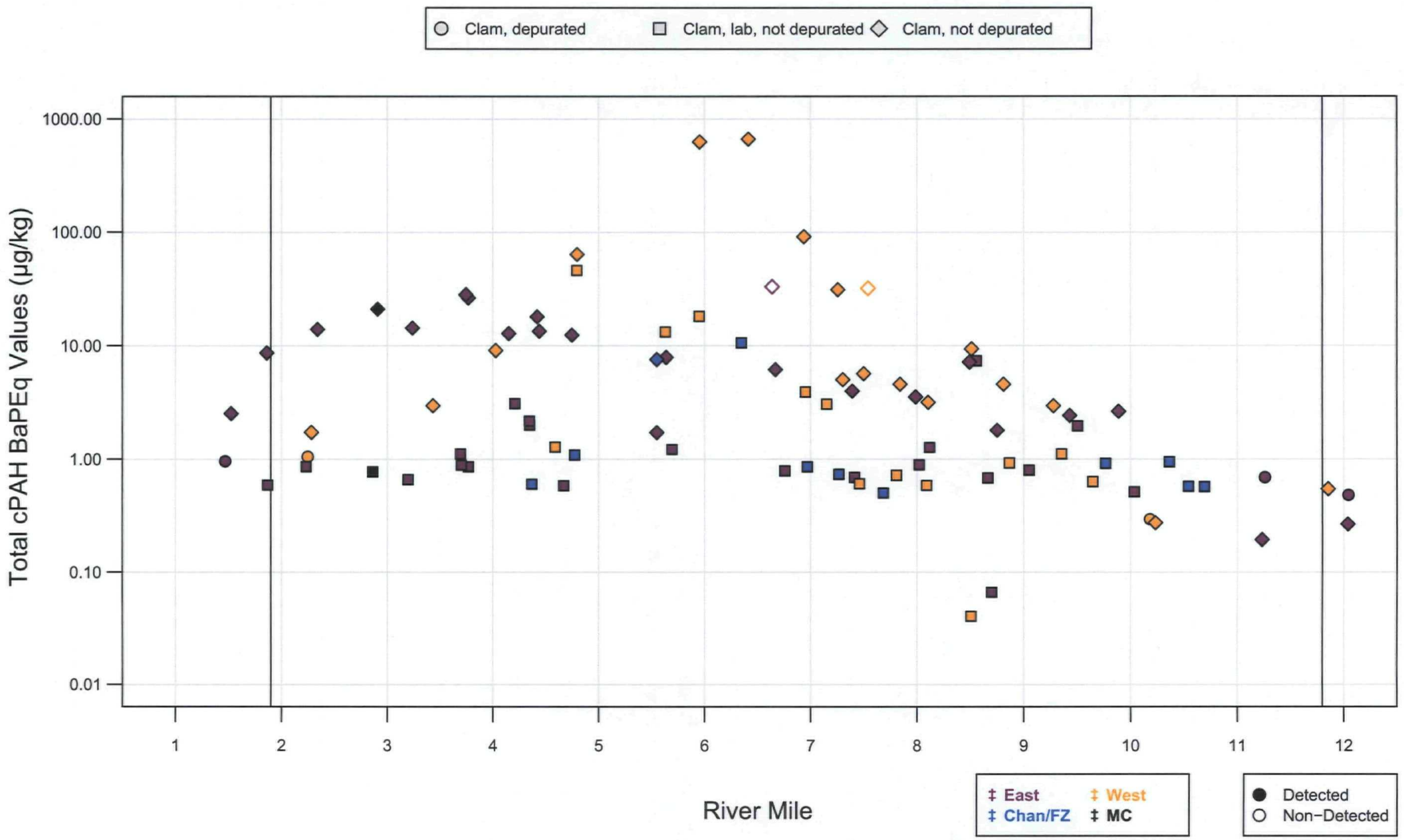

Figure D5.2−11

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Total cPAH BaPEq Values in Tissue Samples by River Mile, RM 0.8−12.2

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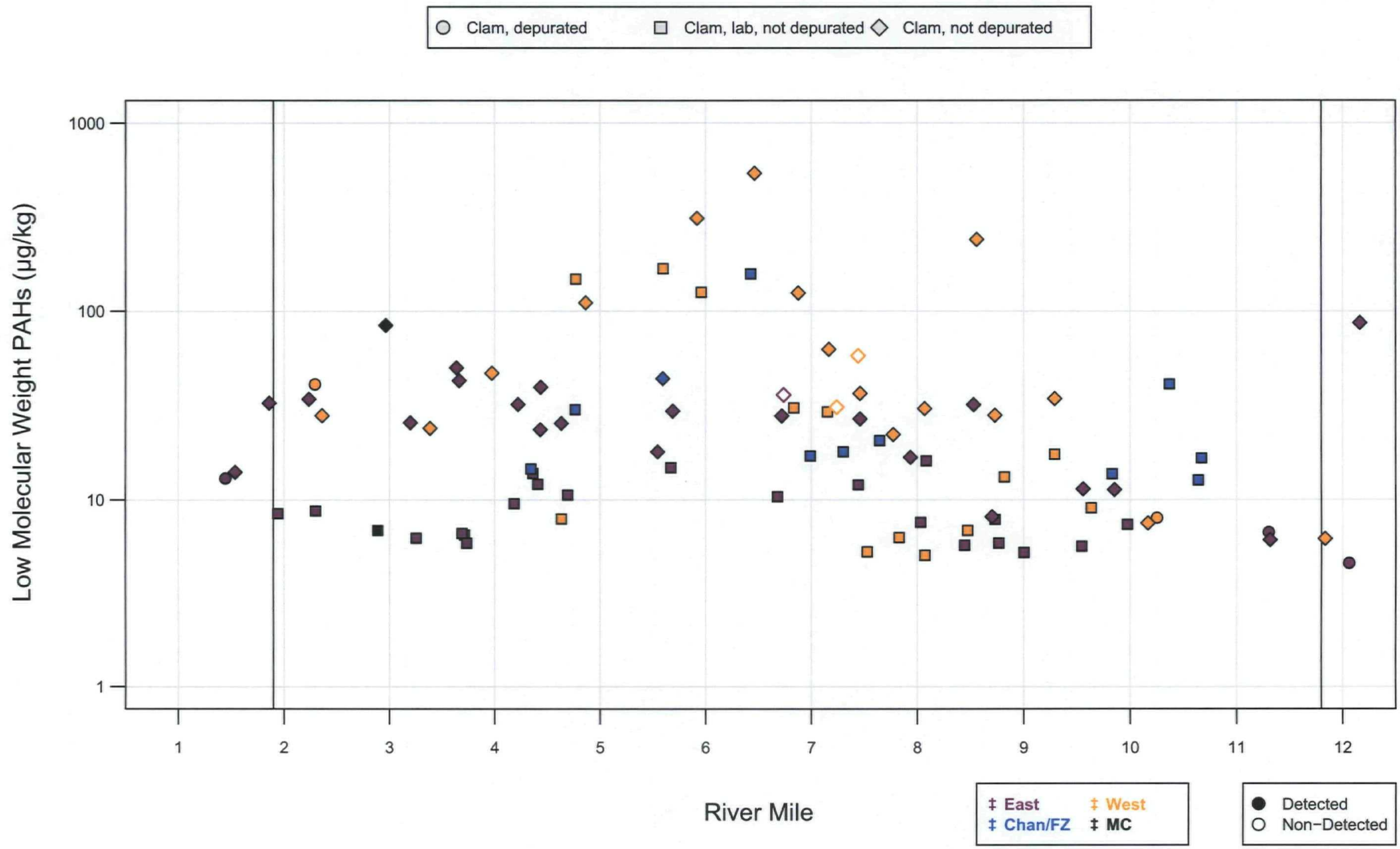

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Figure D5.2-12
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Low Molecular Weight PAHs in Tissue Samples by River Mile, RM 0.8-12.2

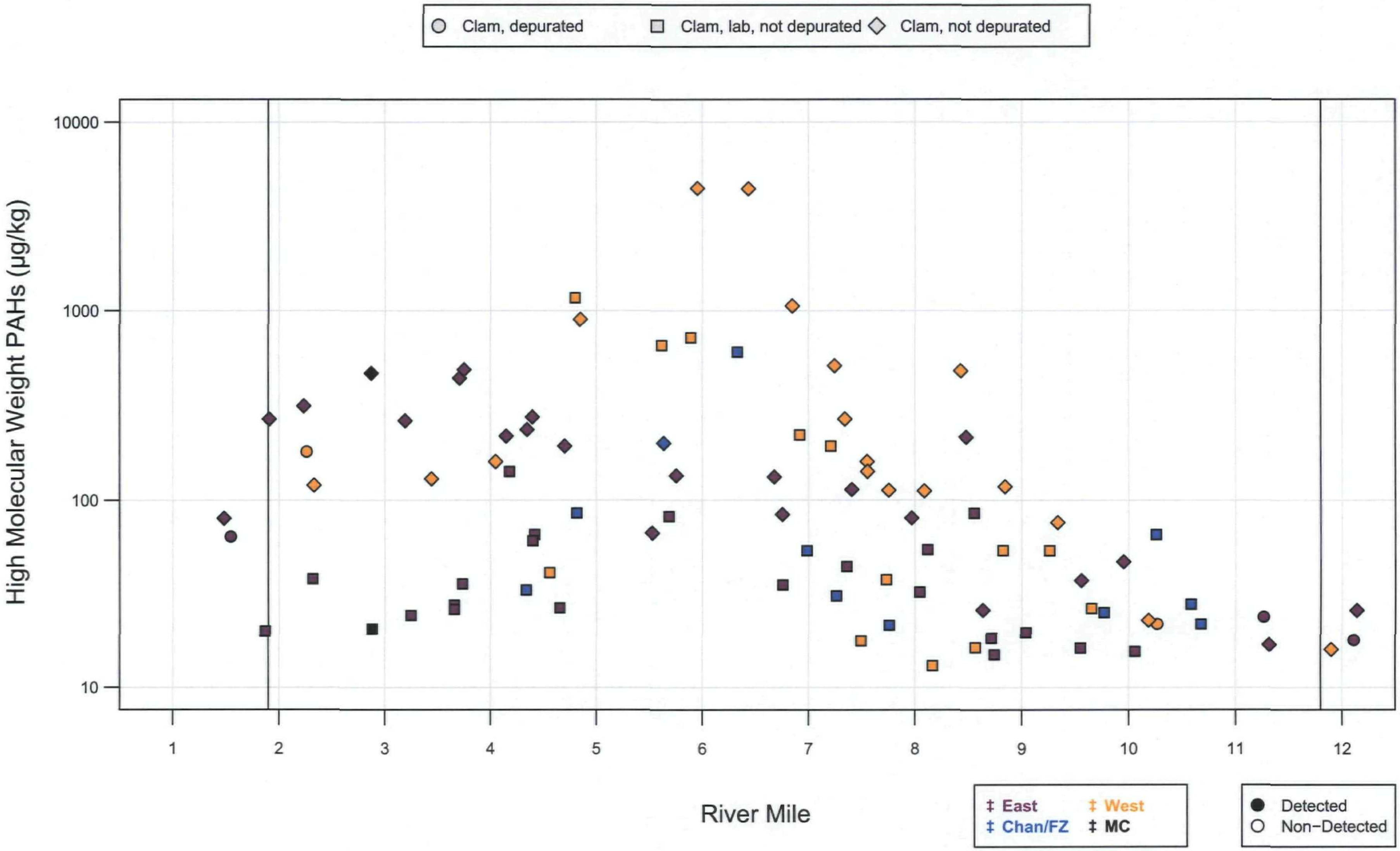

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Figure D5.2-13

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of High Molecular Weight PAHs in Tissue Samples by River Mile, RM 0.8-12.2

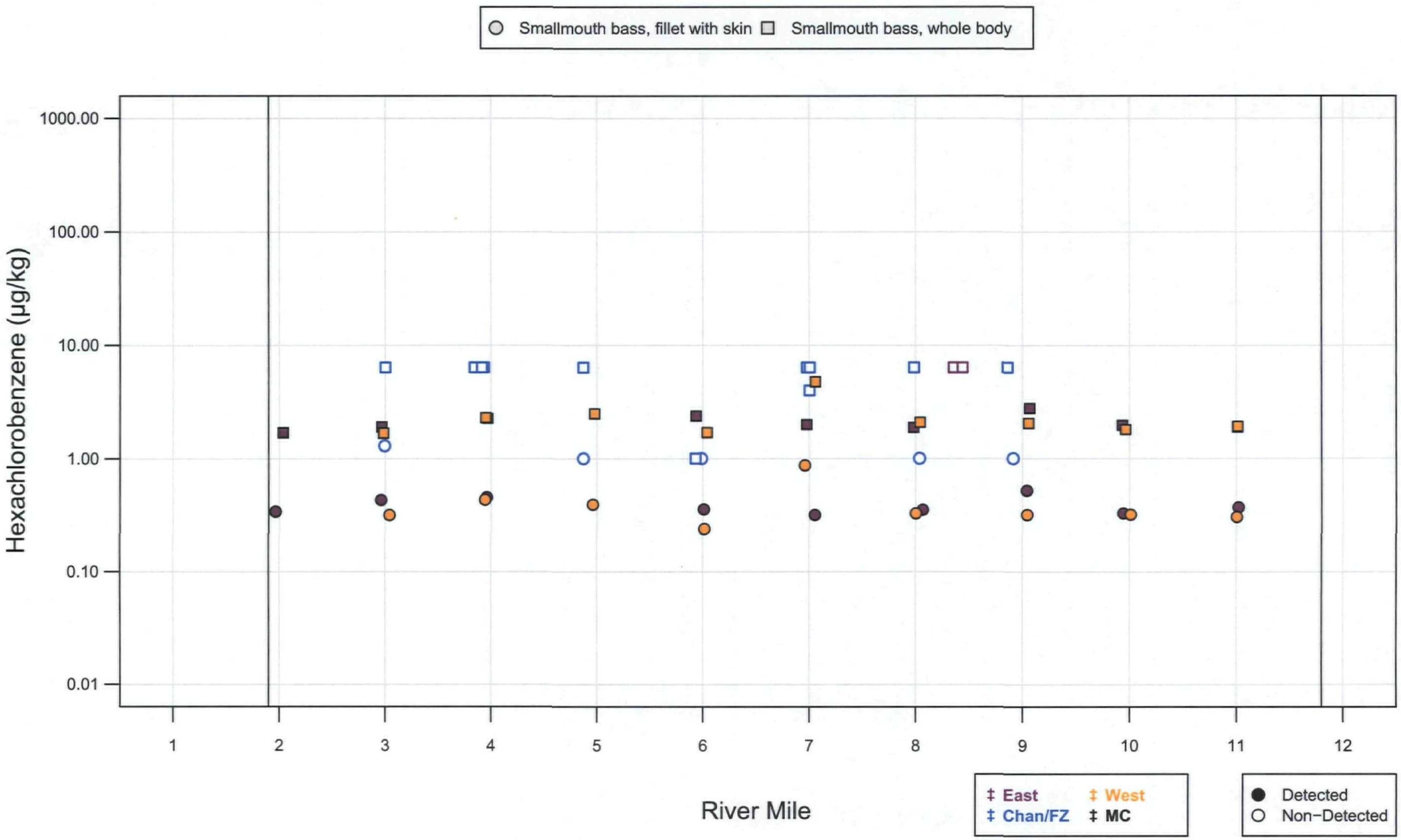

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Figure D5.2-14a

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Scatter Plot of Hexachlorobenzene in Tissue Samples by River Mile, RM 0.8-12.2

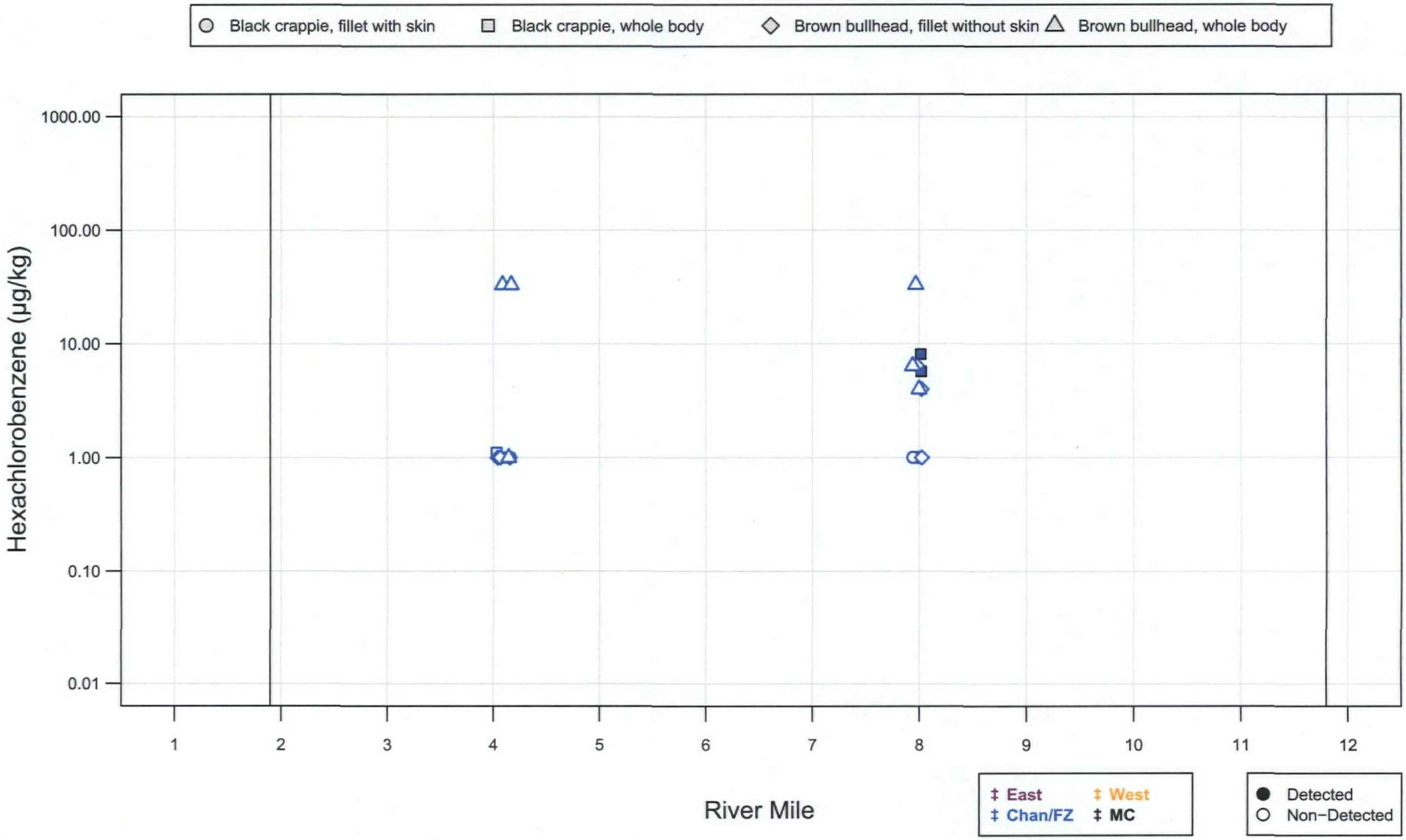

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Figure D5.2−14b

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Hexachlorobenzene in
Tissue Samples by River Mile, RM 0.8−12.2

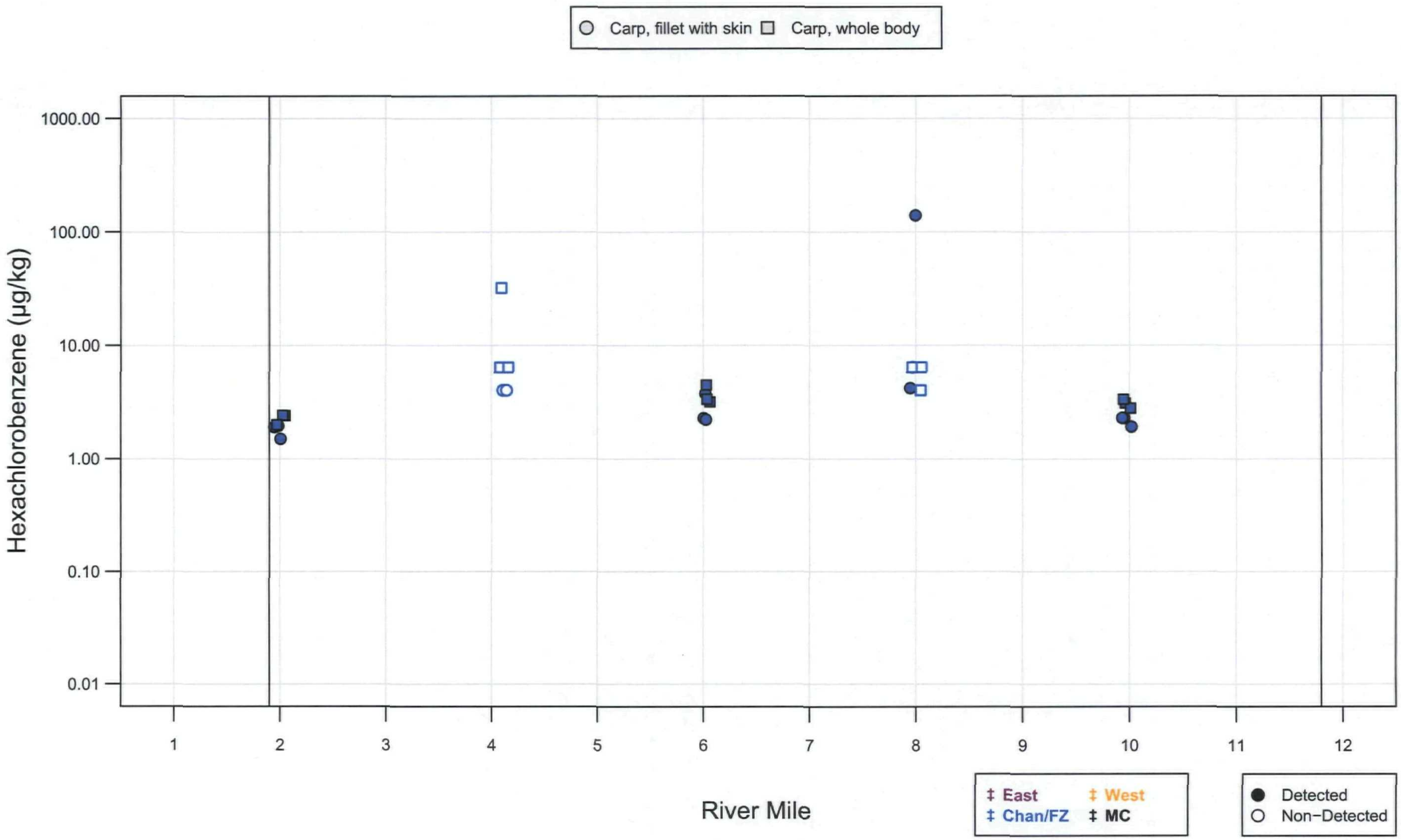

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Figure D5.2−14c

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Hexachlorobenzene in
Tissue Samples by River Mile, RM 0.8−12.2

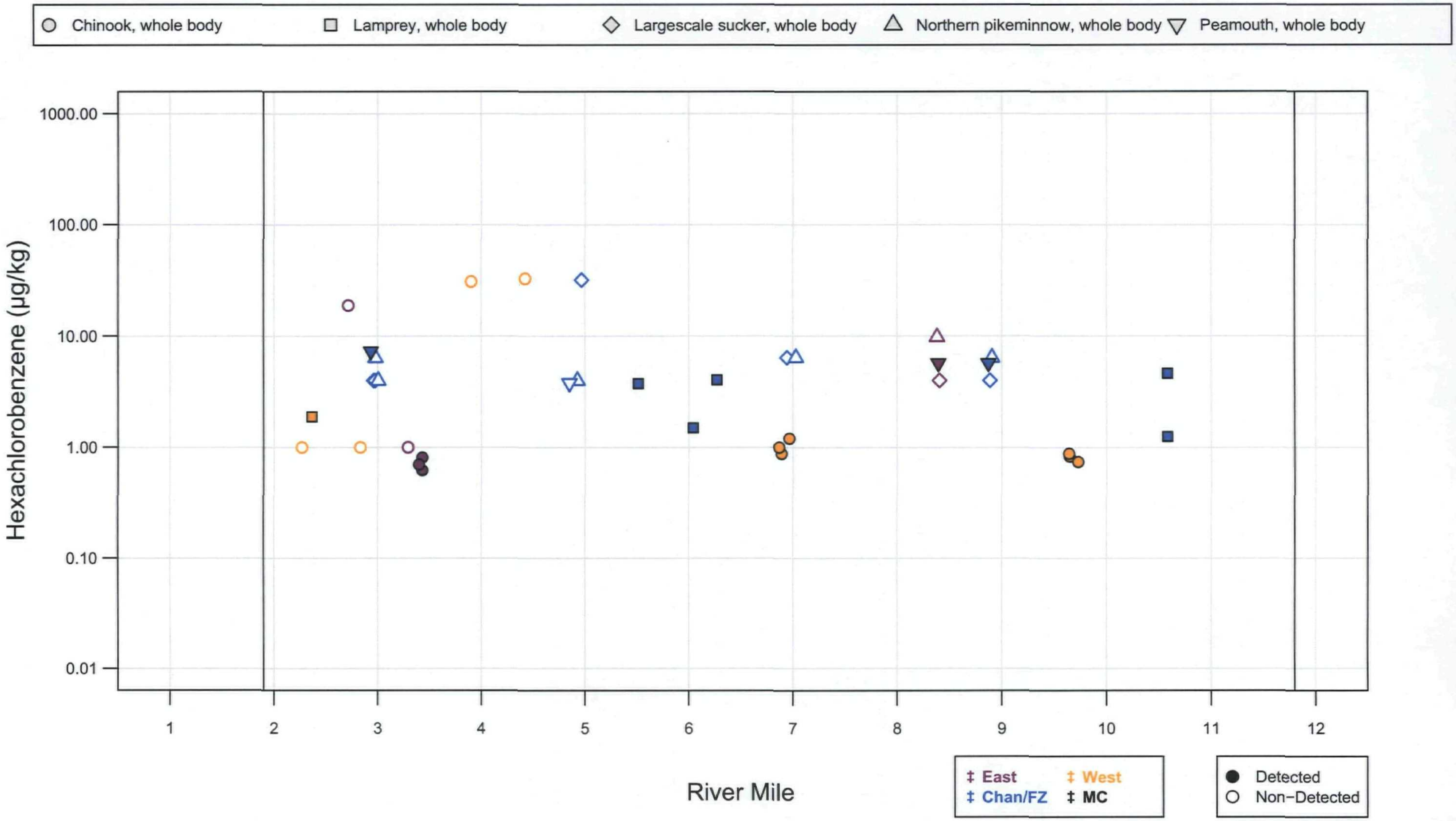

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Figure D5.2-14d
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Hexachlorobenzene in Tissue Samples by River Mile, RM 0.8-12.2

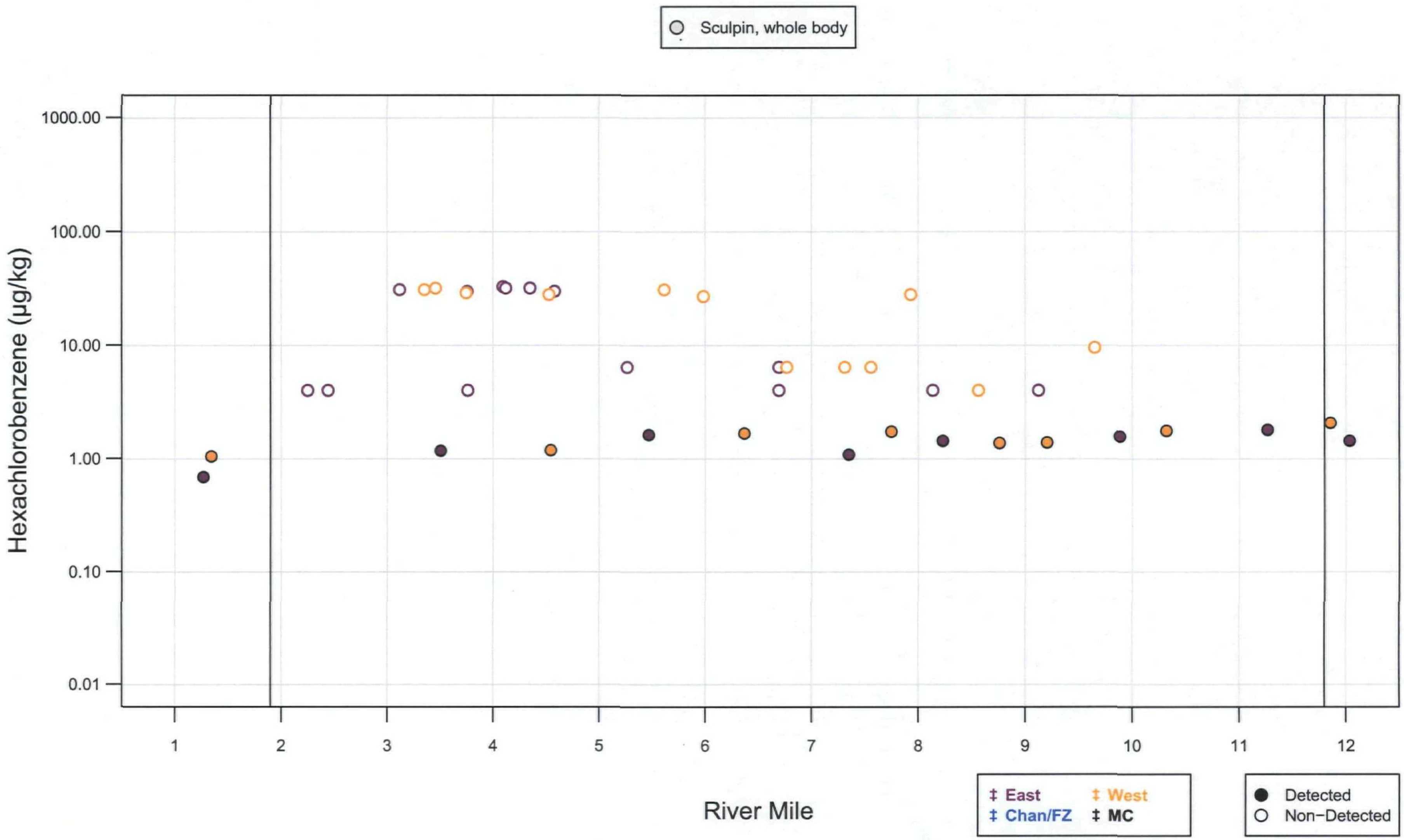

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Figure D5.2−14e
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Hexachlorobenzene in Tissue Samples by River Mile, RM 0.8−12.2

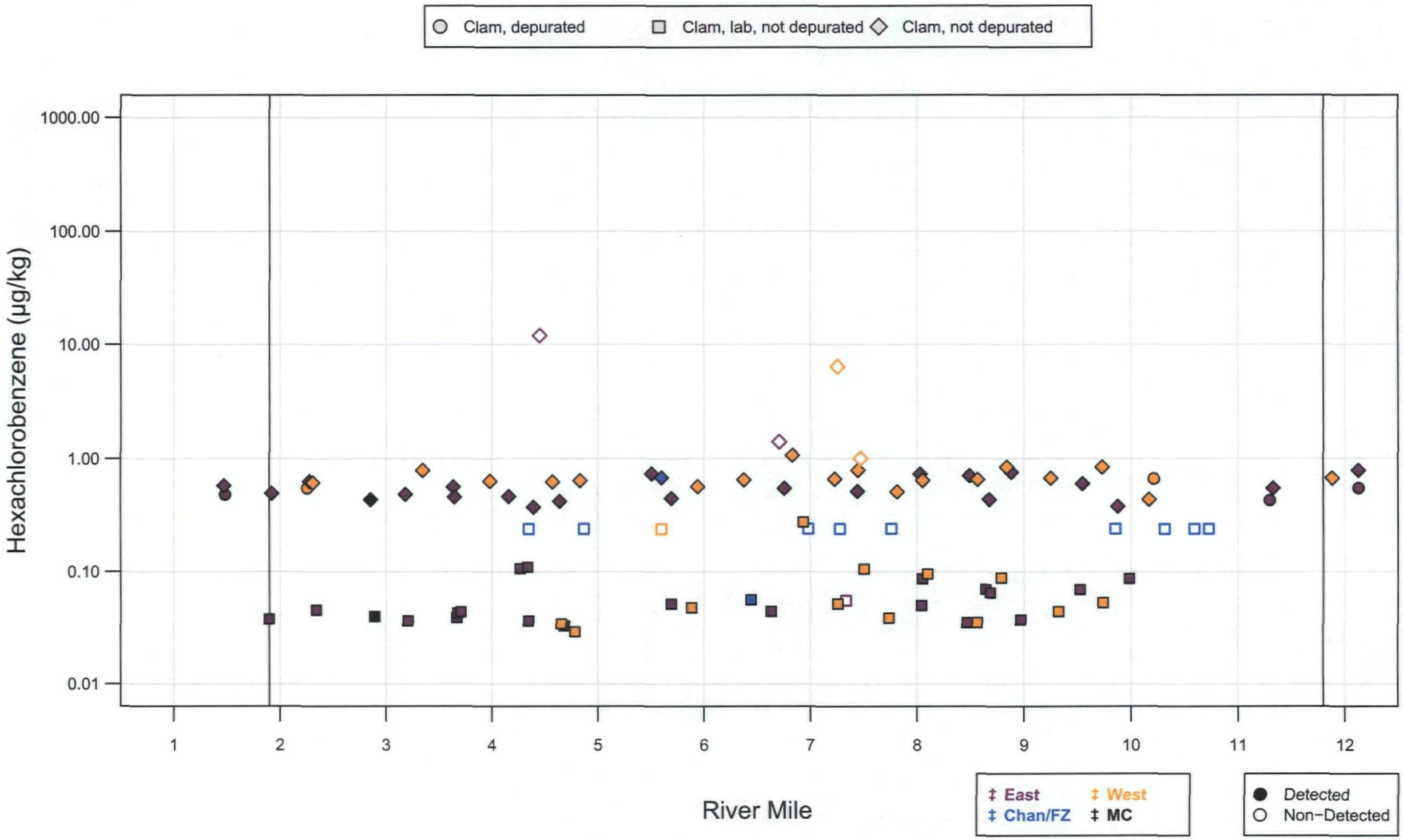

Figure D5.2-14f
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Hexachlorobenzene in Tissue Samples by River Mile, RM 0.8-12.2

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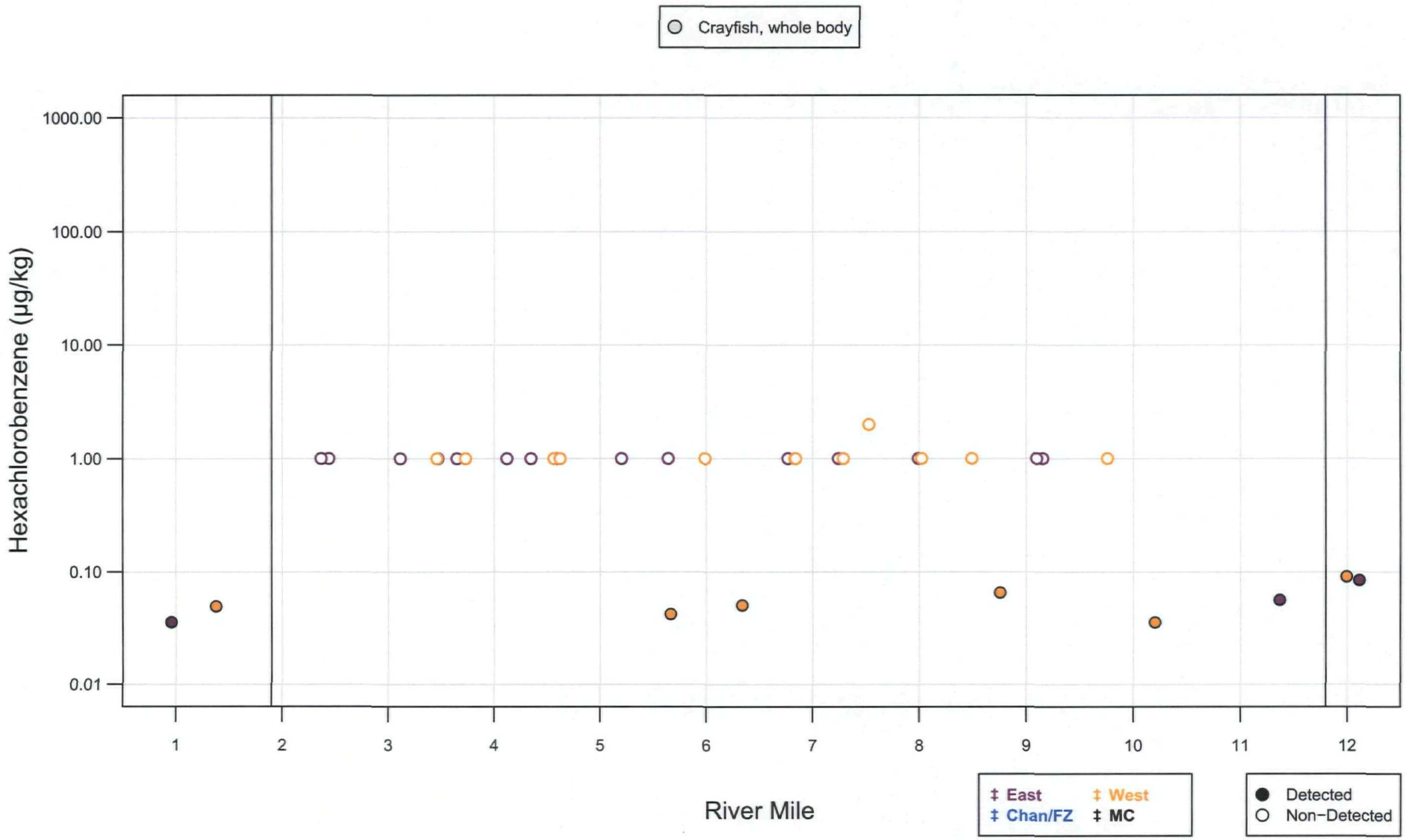

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Figure D5.2-14g

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Draft Remedial Investigation Report
Scatter Plot of Hexachlorobenzene in
Tissue Samples by River Mile, RM 0.8-12.2

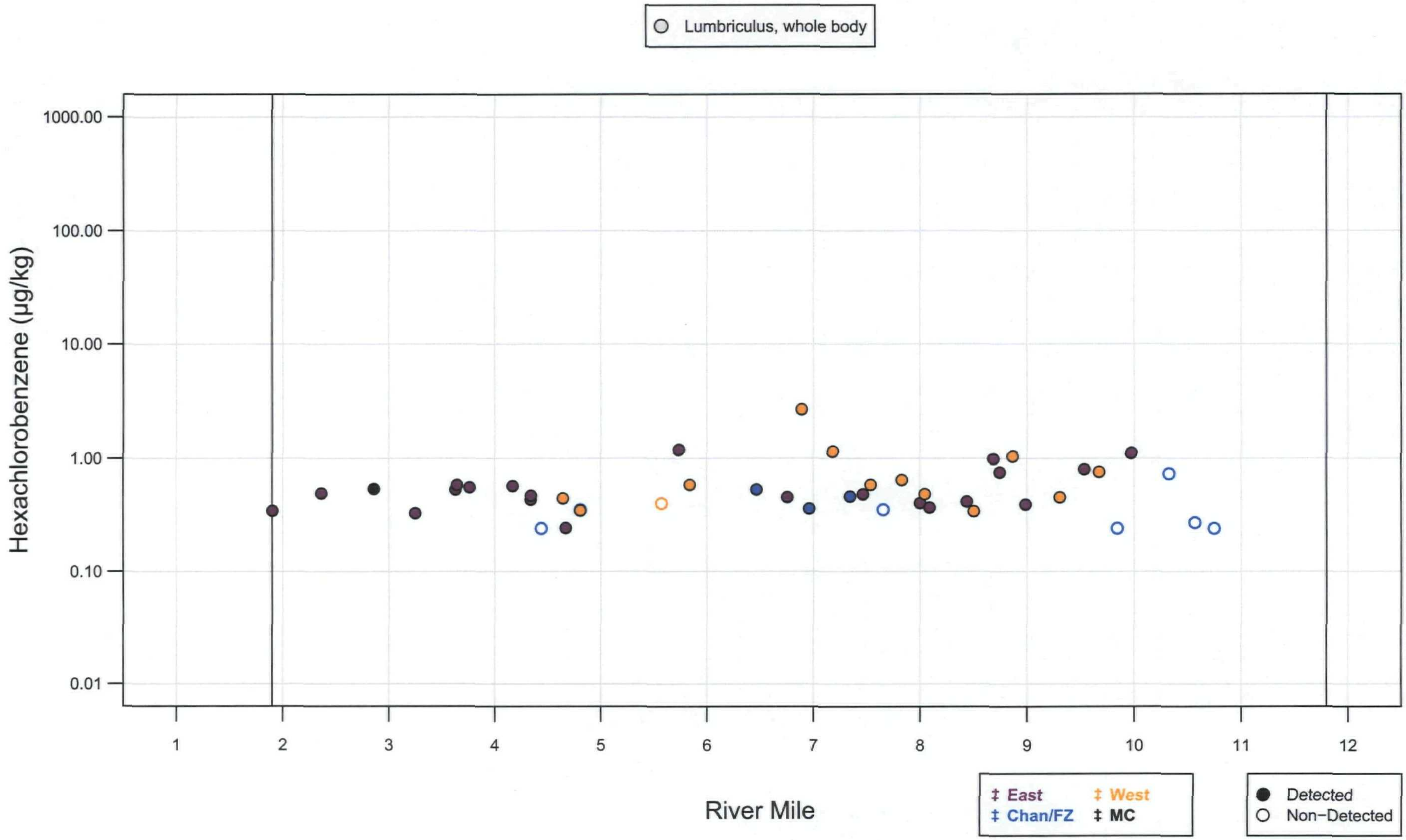

Figure D5.2−14h

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Hexachlorobenzene in
Tissue Samples by River Mile, RM 0.8−12.2

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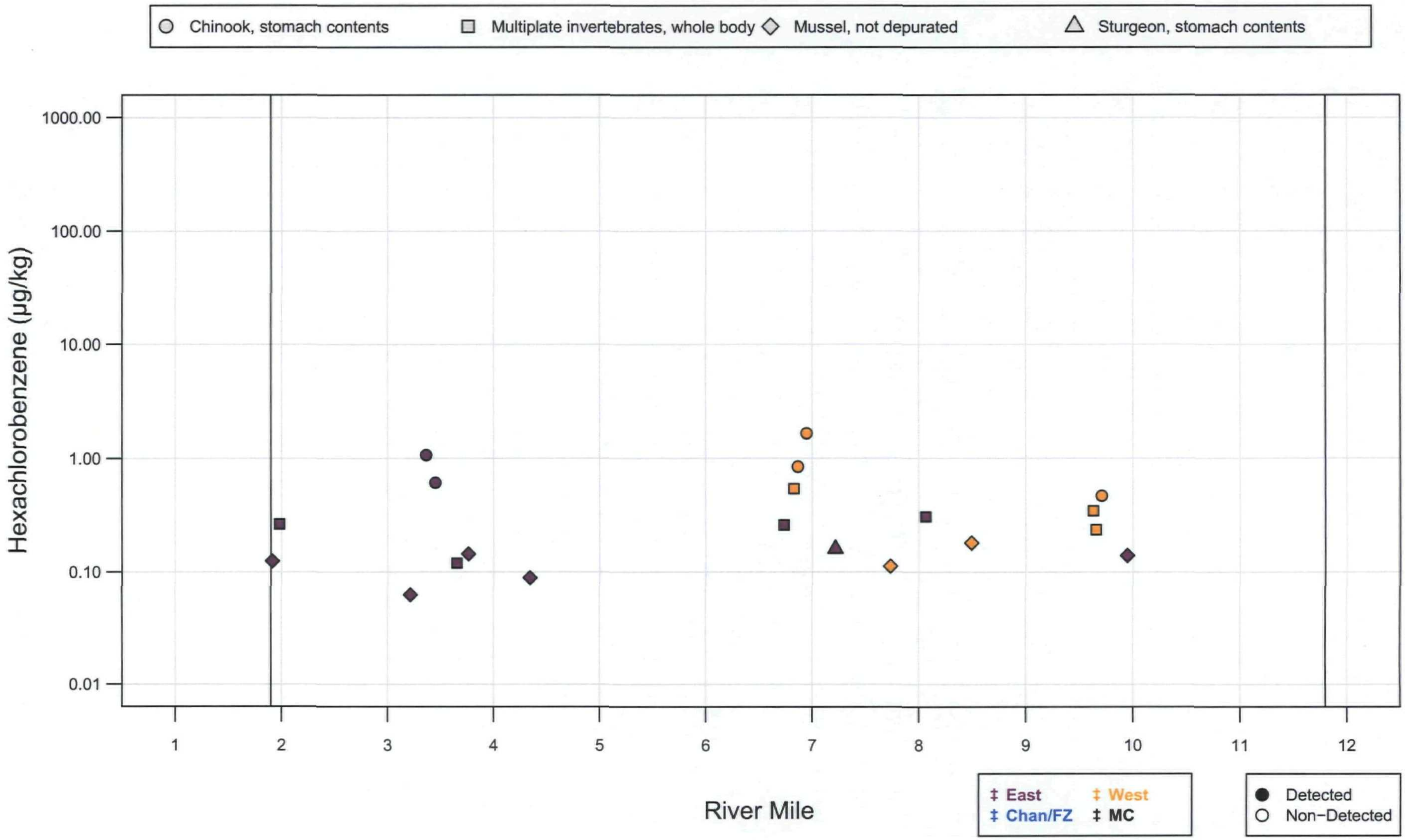

Figure D5.2-14i

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Draft Remedial Investigation Report
Scatter Plot of Hexachlorobenzene in
Tissue Samples by River Mile, RM 0.8-12.2

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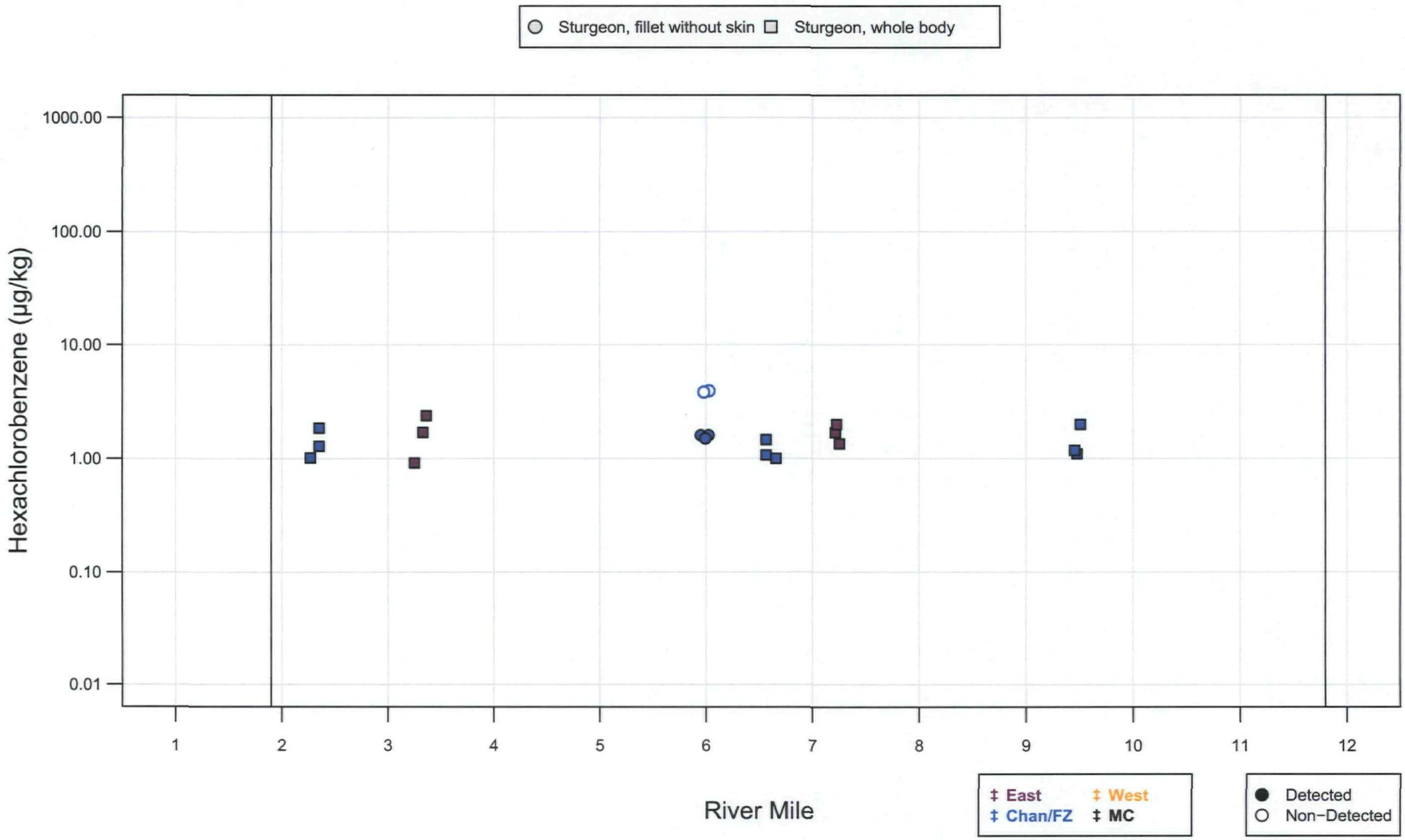

Figure D5.2-14j

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Hexachlorobenzene in
Tissue Samples by River Mile, RM 0.8-12.2

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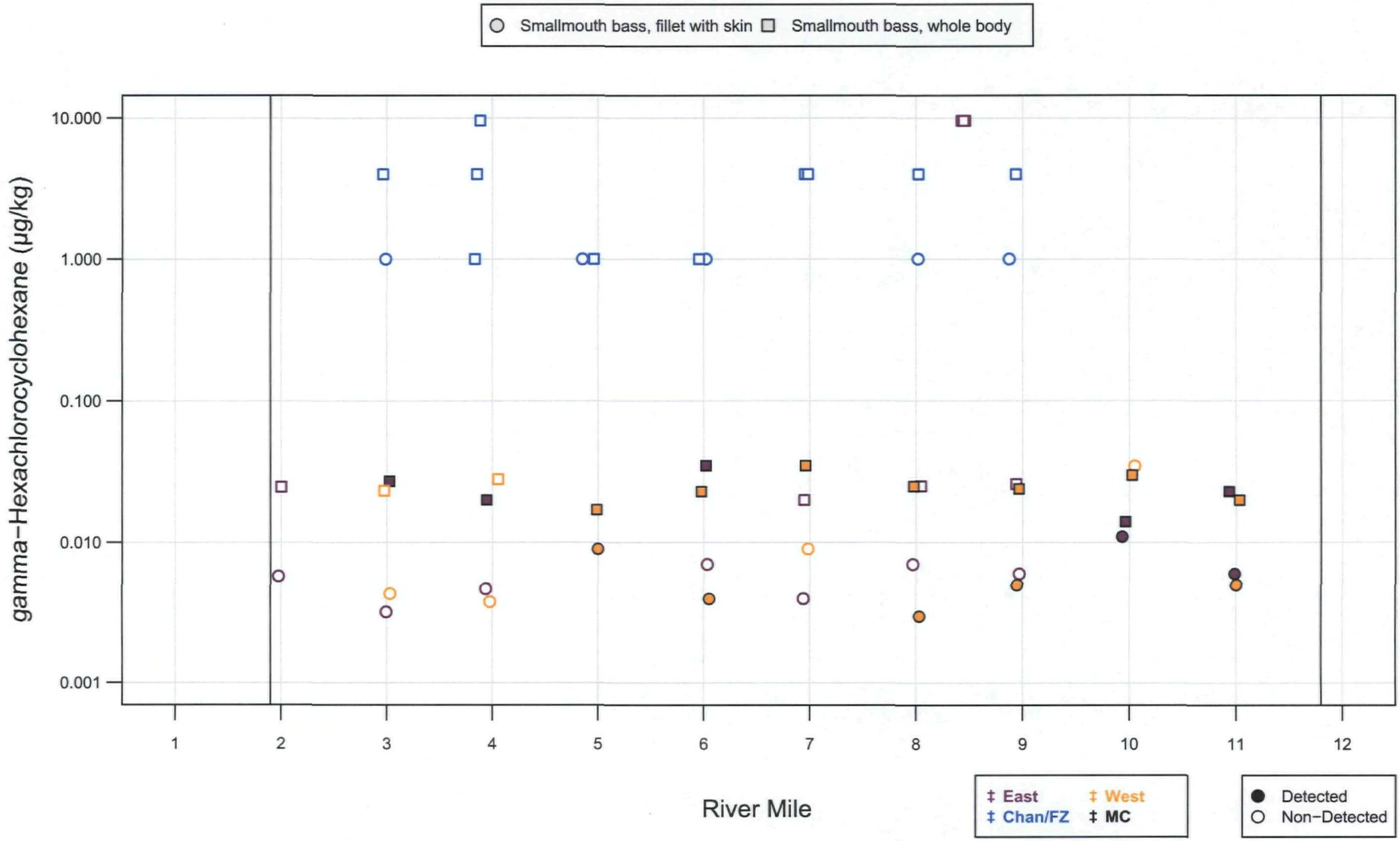

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Figure D5.2-15a
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of gamma-Hexachlorocyclohexane in Tissue Samples by River Mile, RM 0.8-12.2

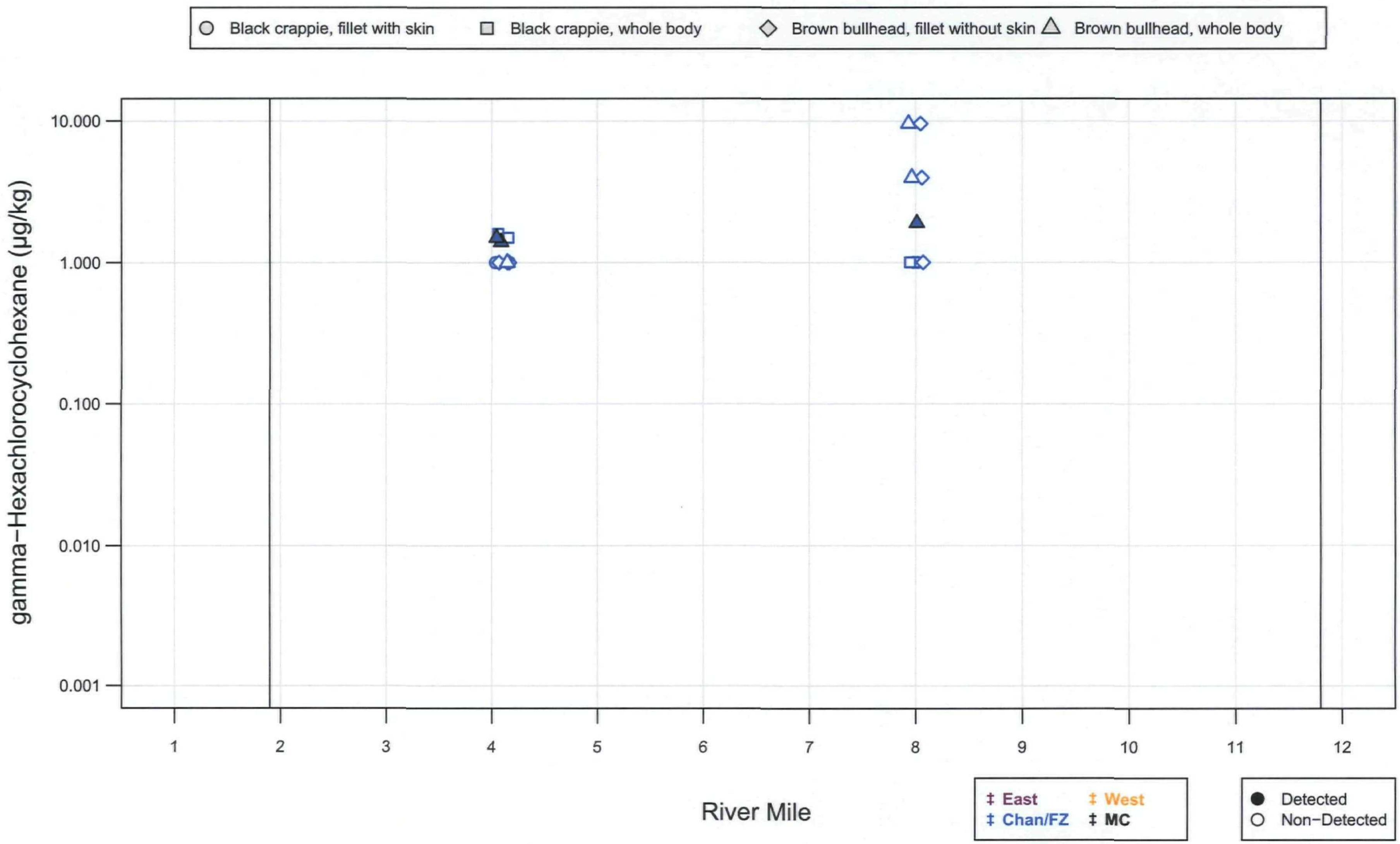

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Figure D5.2−15b
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of gamma−Hexachlorocyclohexane in Tissue Samples by River Mile, RM 0.8−12.2

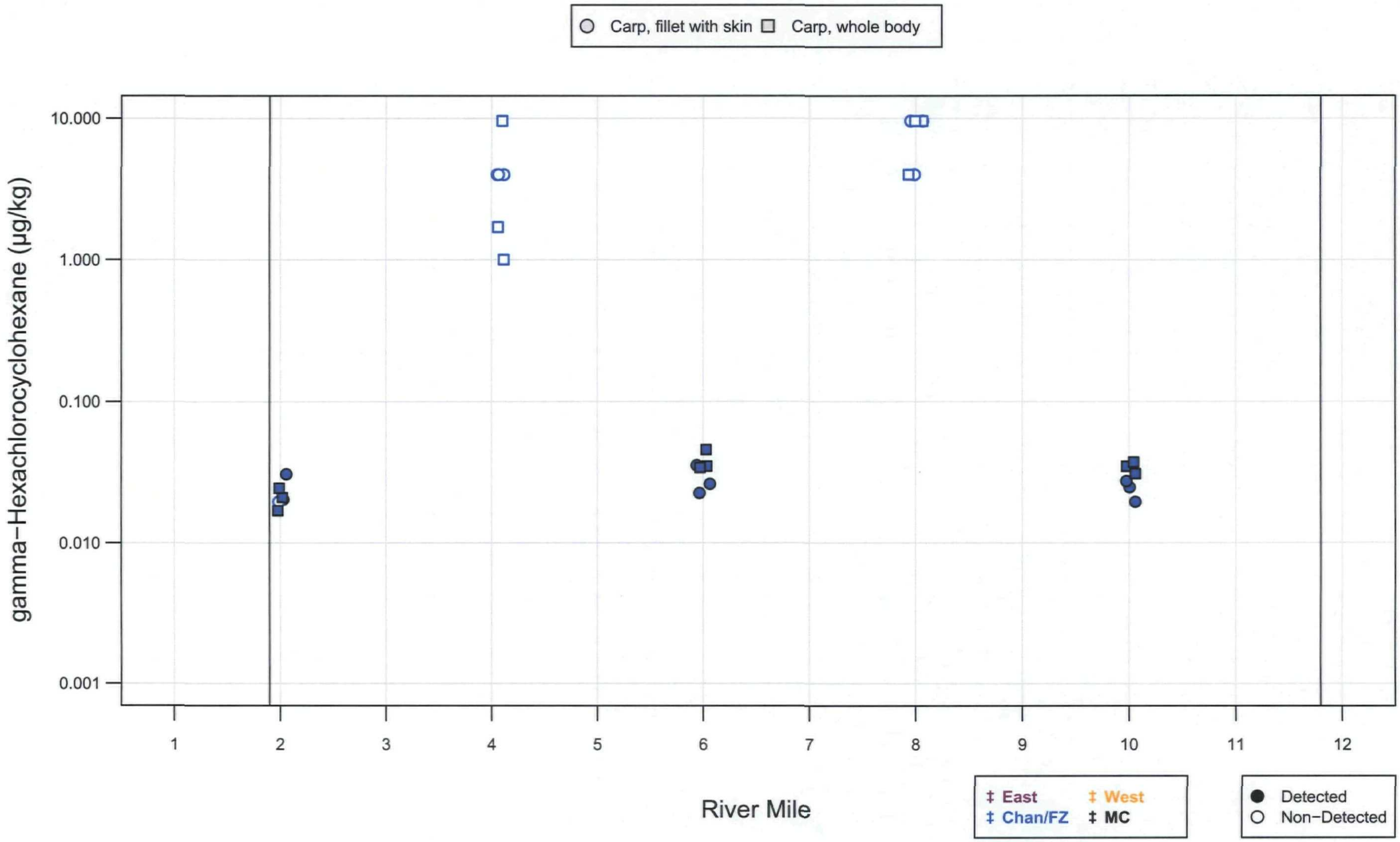

Figure D5.2−15c

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of gamma−Hexachlorocyclohexane in Tissue Samples by River Mile, RM 0.8−12.2

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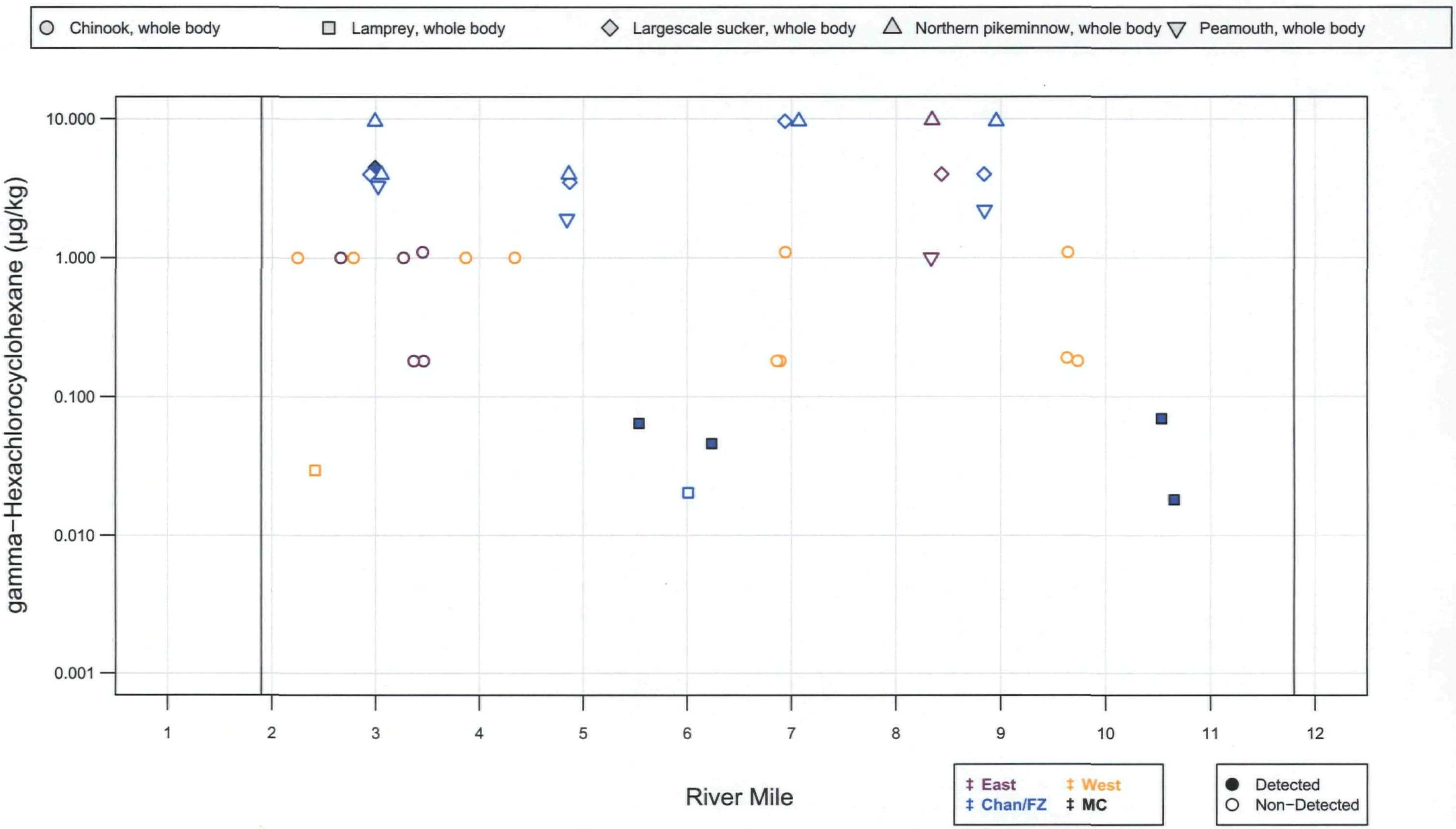

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Figure D5.2−15d

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of gamma−Hexachlorocyclohexane in Tissue Samples by River Mile, RM 0.8−12.2

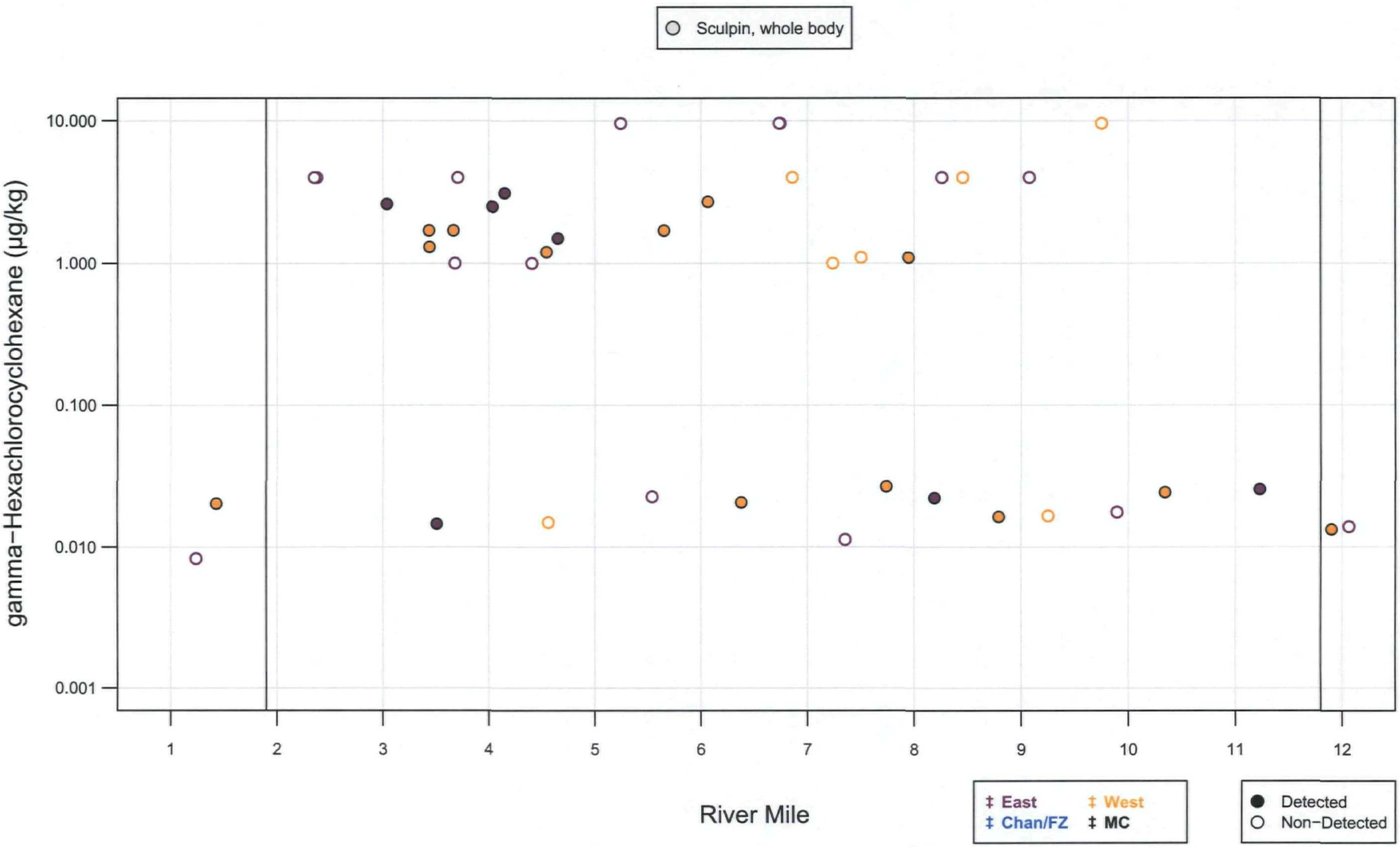

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Figure D5.2−15e
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of gamma−Hexachlorocyclohexane in Tissue Samples by River Mile, RM 0.8−12.2

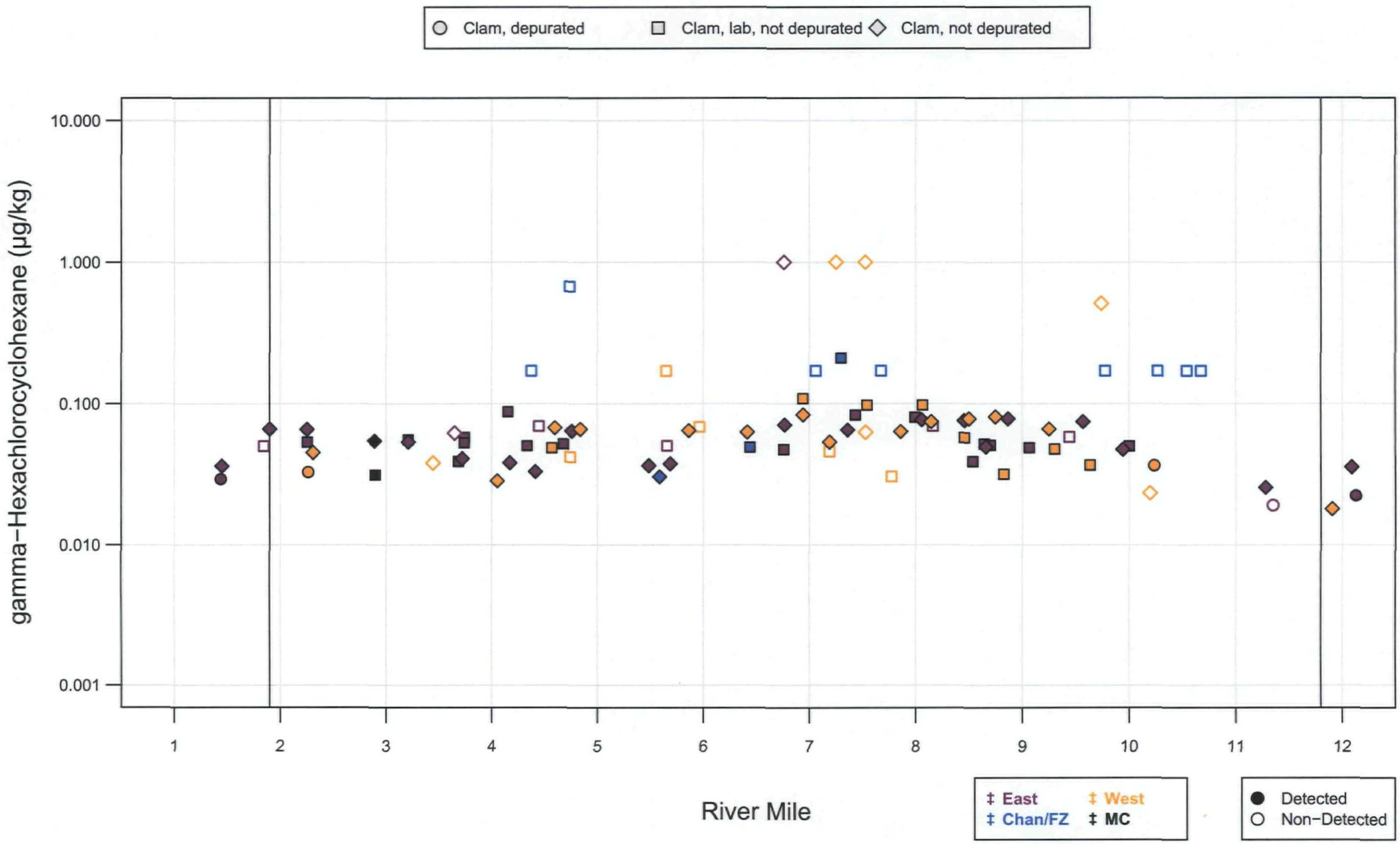

Figure D5.2-15f

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of gamma-Hexachlorocyclohexane in Tissue Samples by River Mile, RM 0.8-12.2

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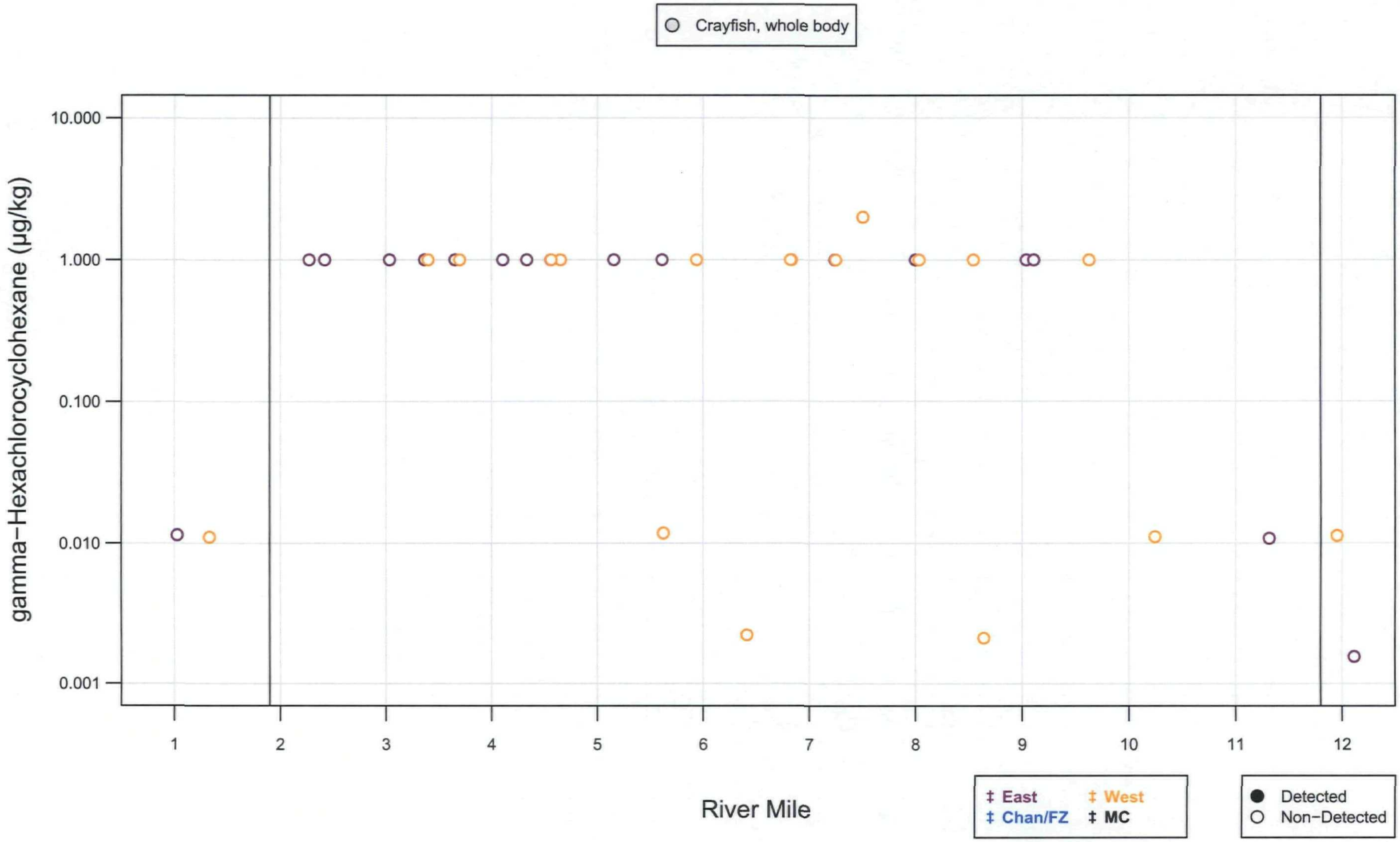

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Figure D5.2−15g

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of gamma−Hexachlorocyclohexane in Tissue Samples by River Mile, RM 0.8−12.2

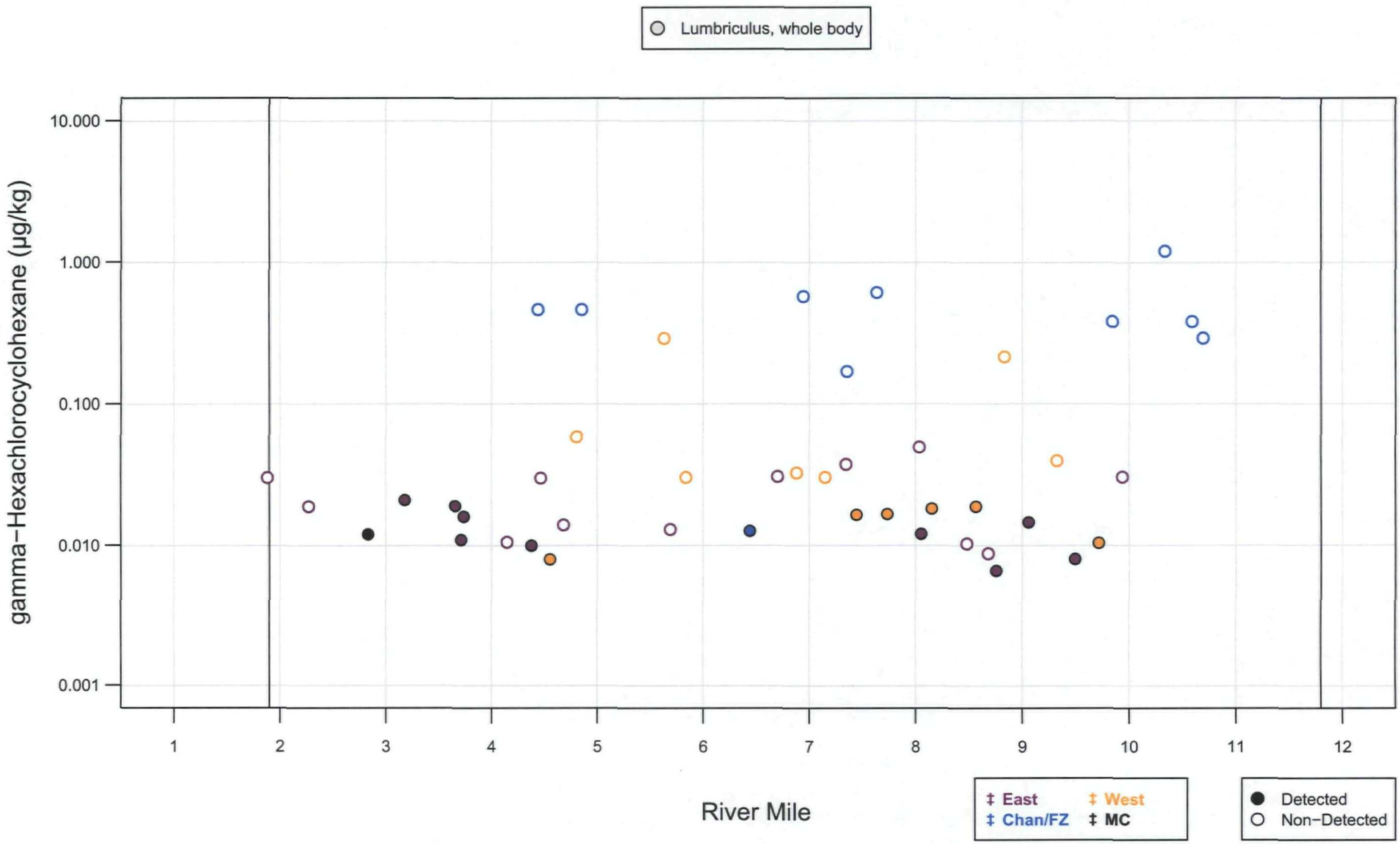

Figure D5.2−15h

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of gamma−Hexachlorocyclohexane in Tissue Samples by River Mile, RM 0.8−12.2

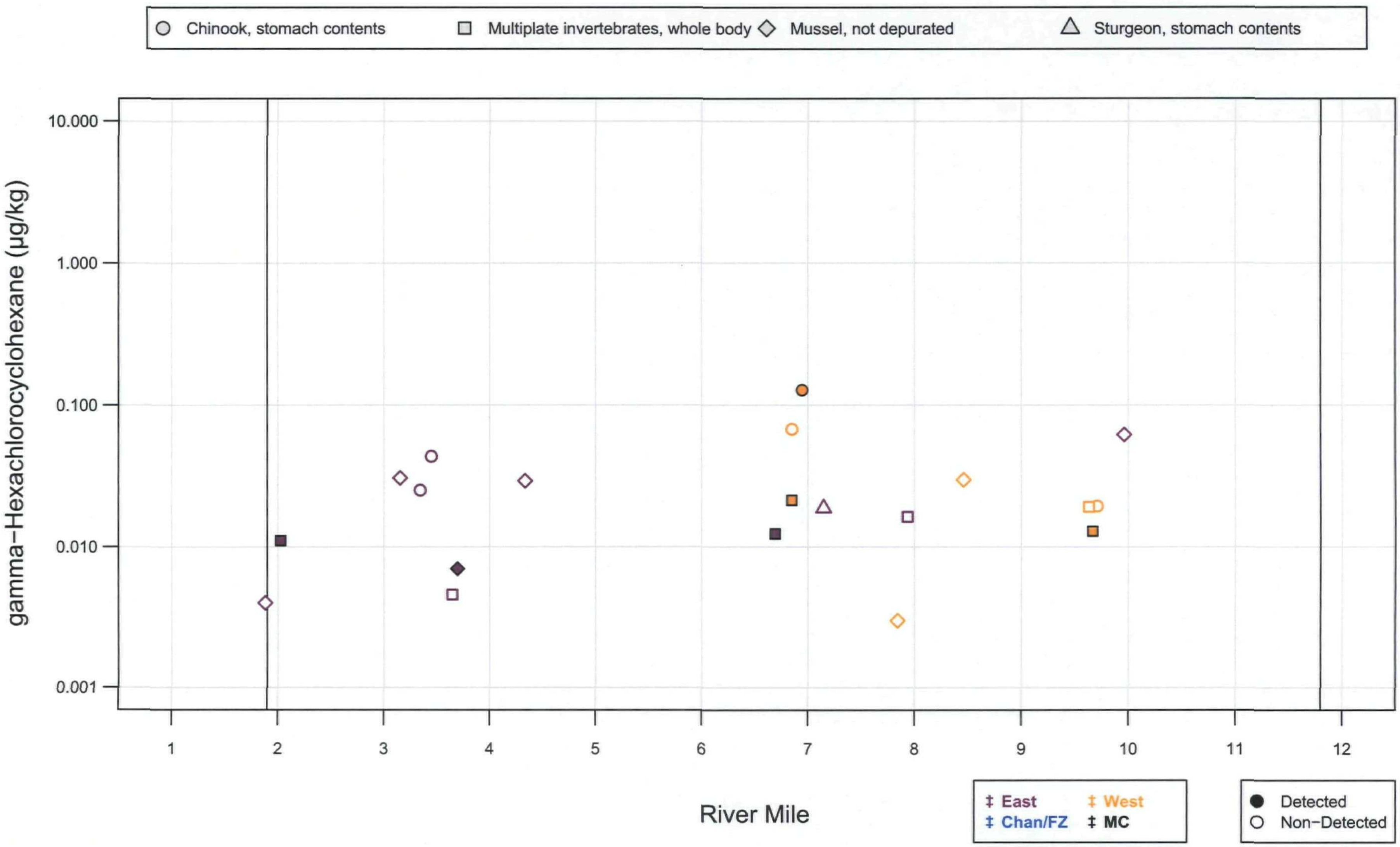

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Figure D5.2−15i
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of gamma−Hexachlorocyclohexane in Tissue Samples by River Mile, RM 0.8−12.2

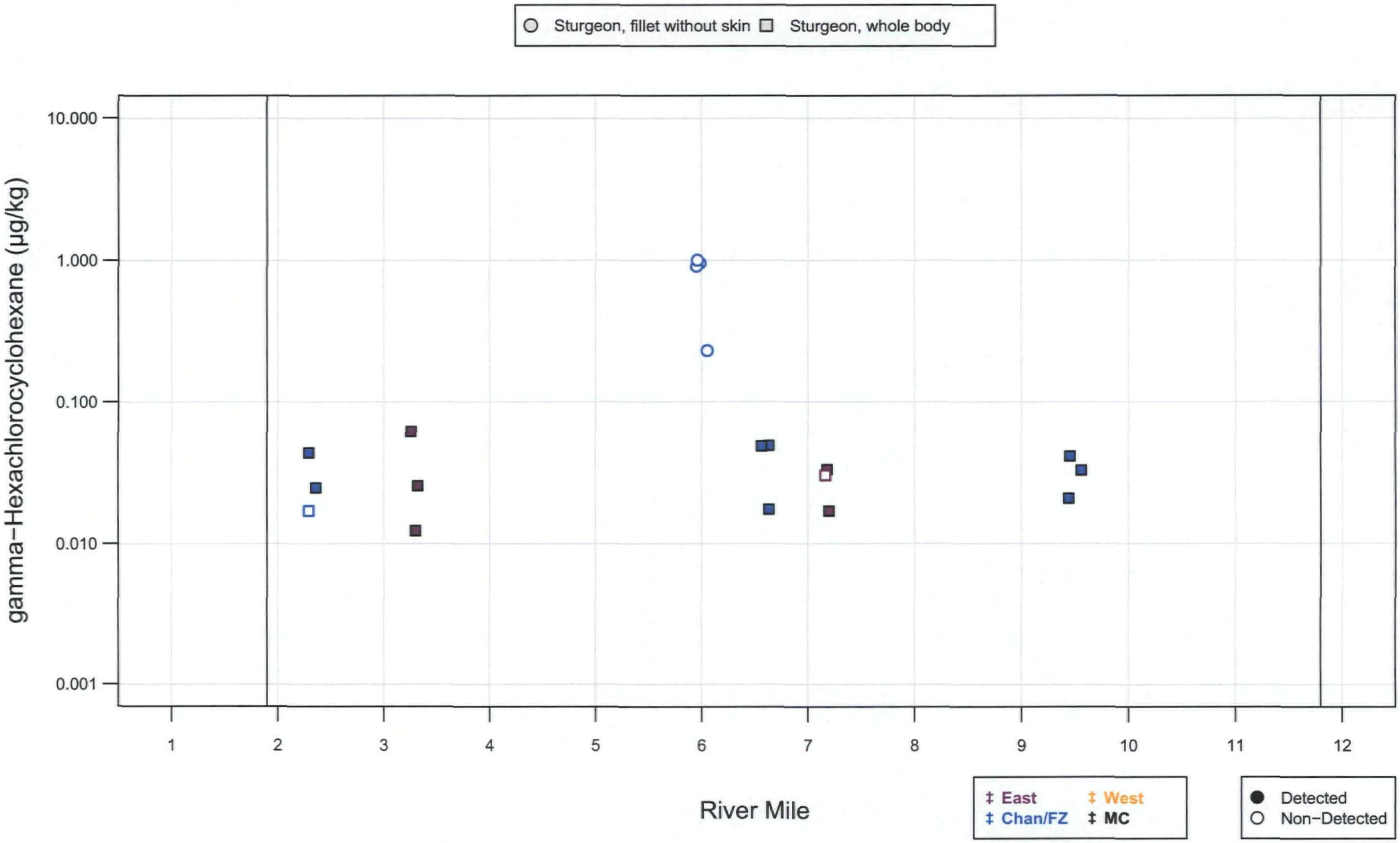

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Figure D5.2-15j
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of gamma-Hexachlorocyclohexane in Tissue Samples by River Mile, RM 0.8-12.2

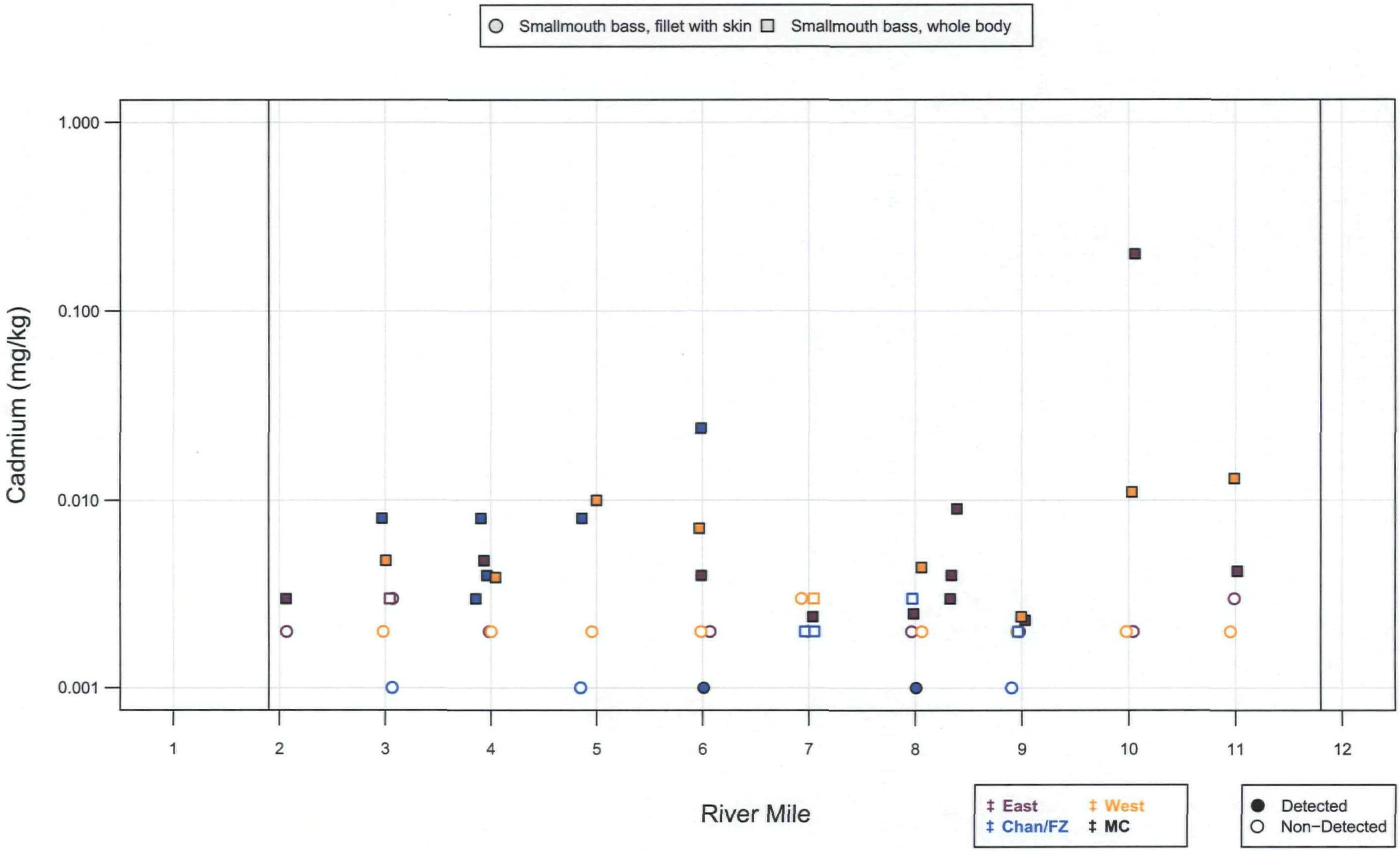

Figure D5.2-16a
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Cadmium in
Tissue Samples by River Mile, RM 0.8-12.2

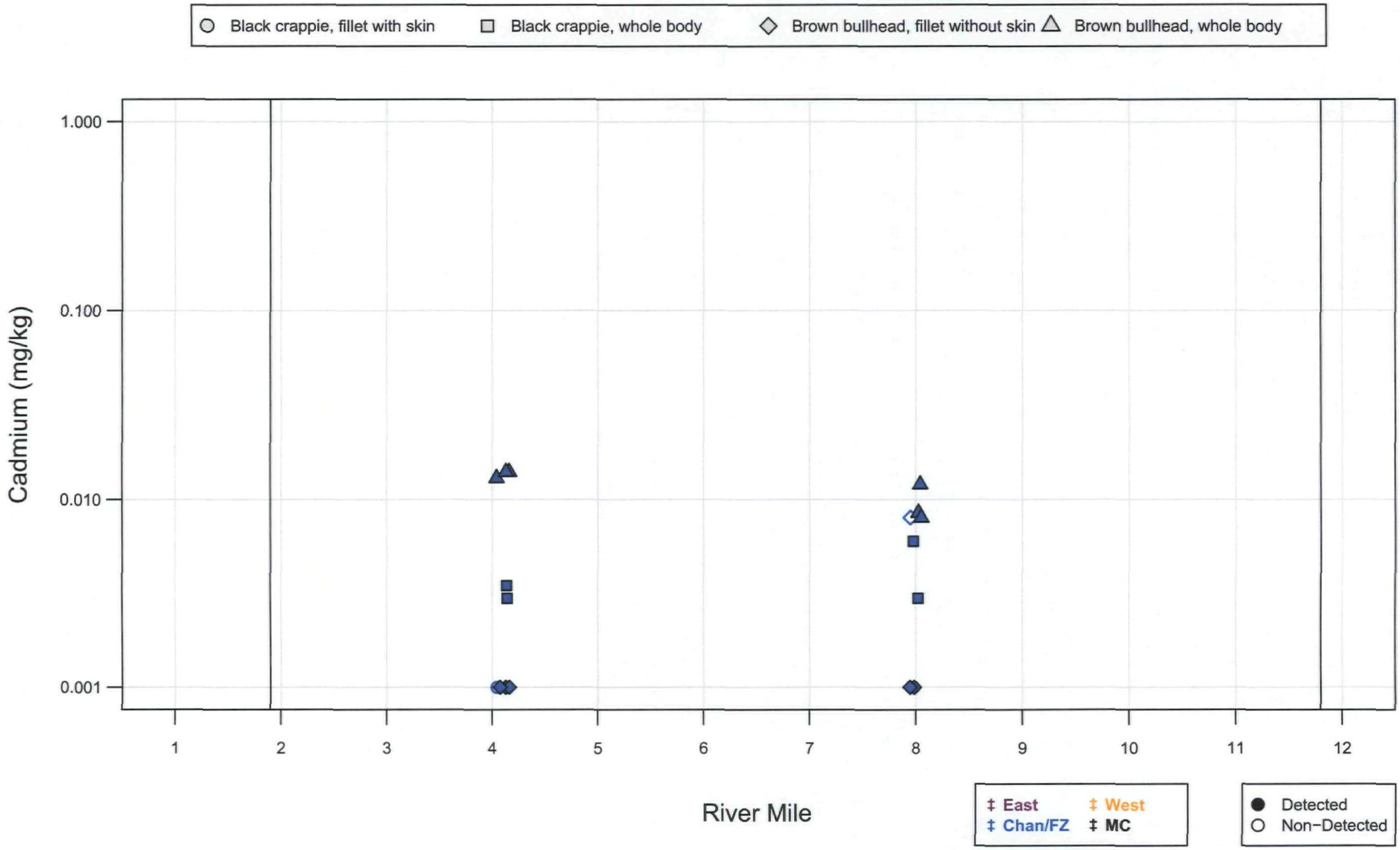

Figure D5.2-16b
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Cadmium in
Tissue Samples by River Mile, RM 0.8-12.2

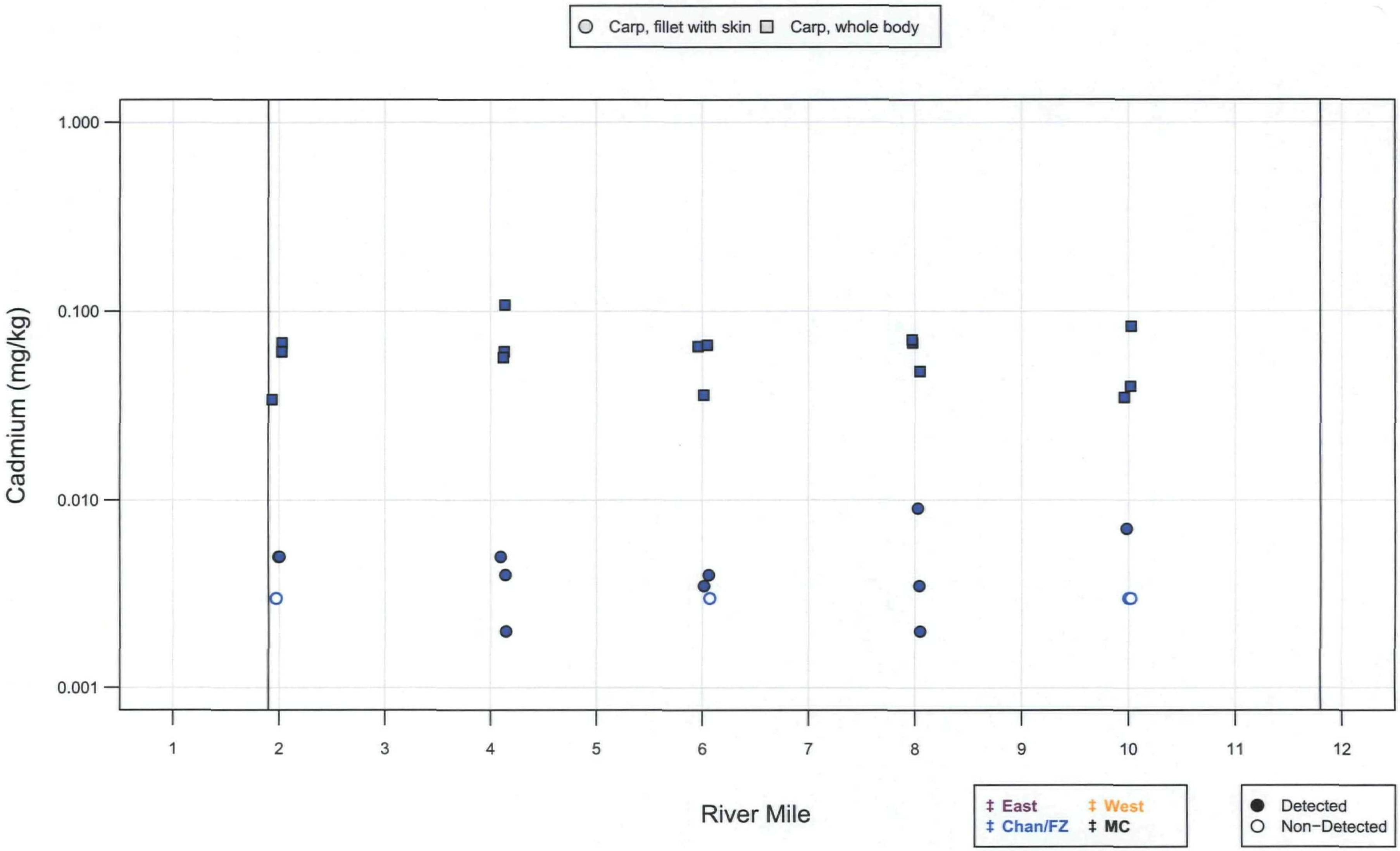

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Figure D5.2-16c

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Cadmium in
Tissue Samples by River Mile, RM 0.8-12.2

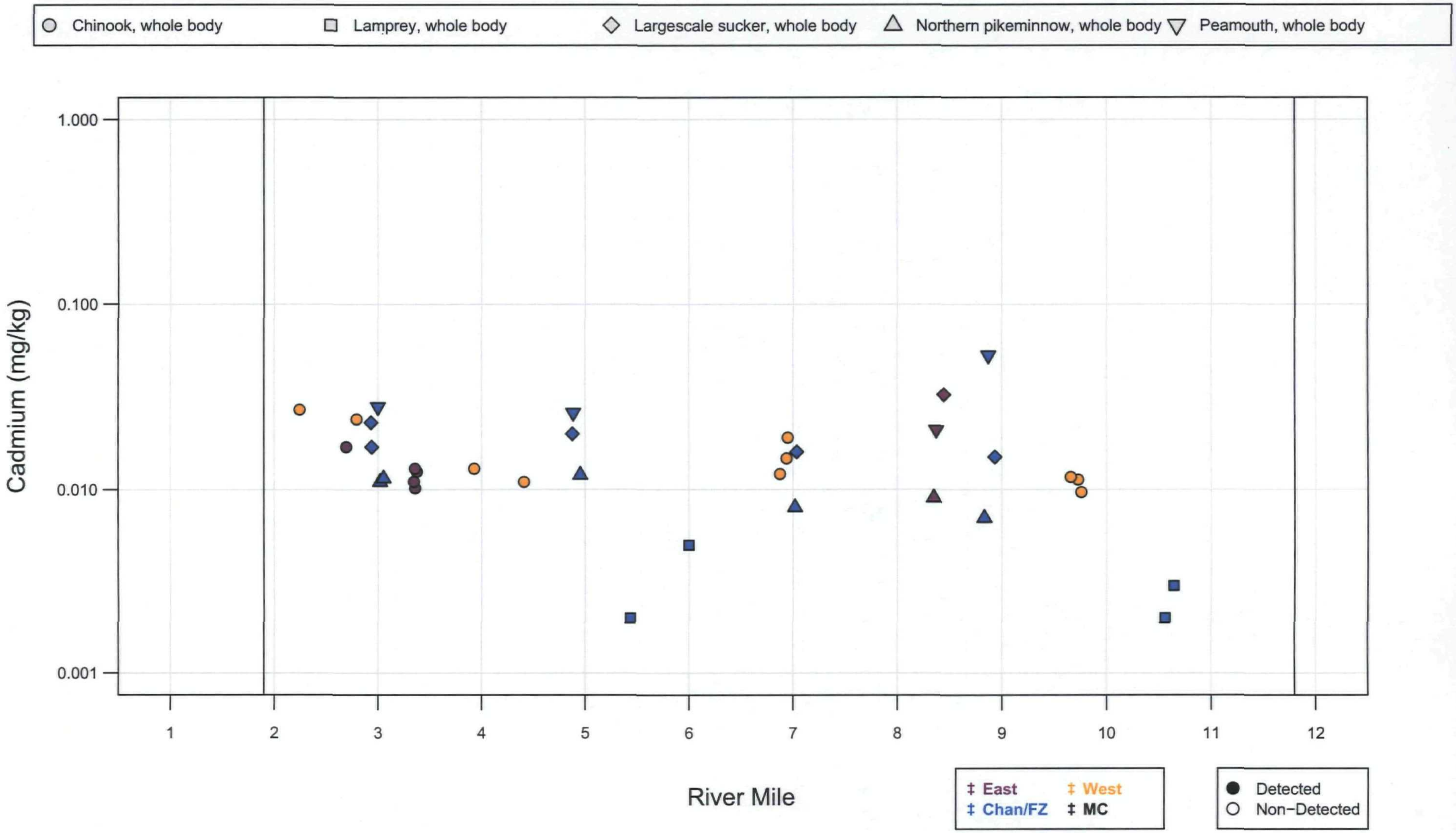

Figure D5.2−16d

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Cadmium in
Tissue Samples by River Mile, RM 0.8−12.2

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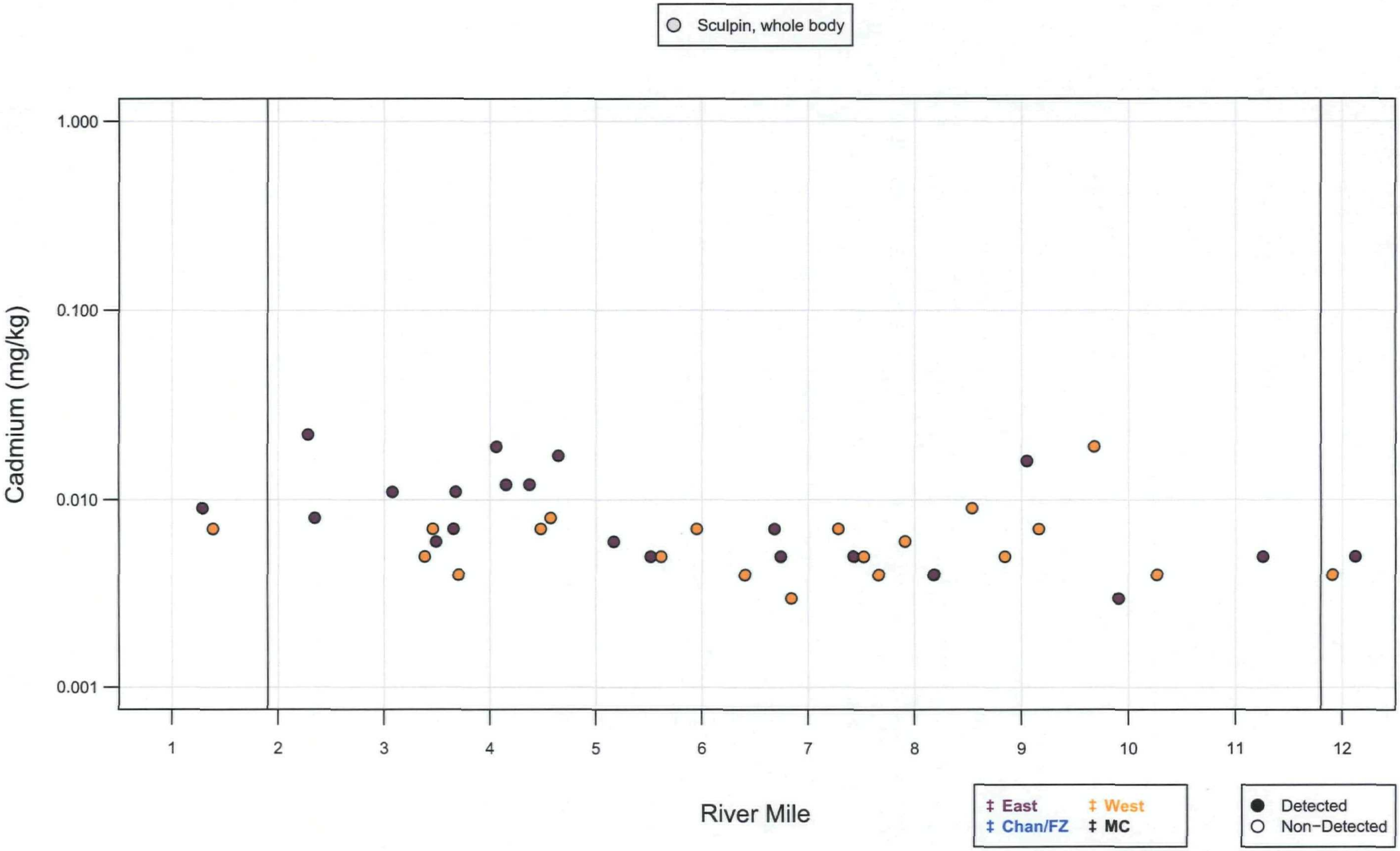
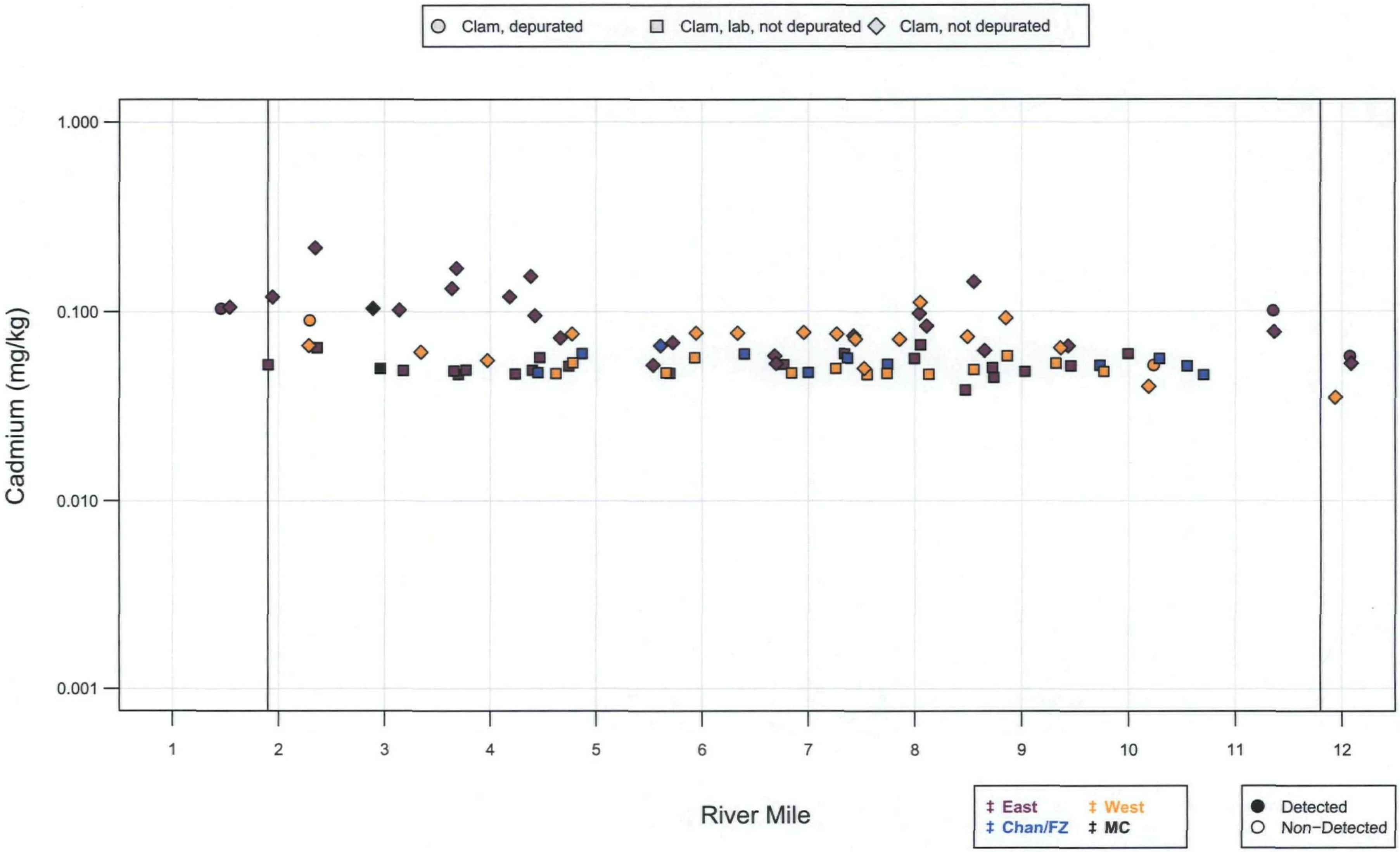


Figure D5.2-16e

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Cadmium in
Tissue Samples by River Mile, RM 0.8-12.2



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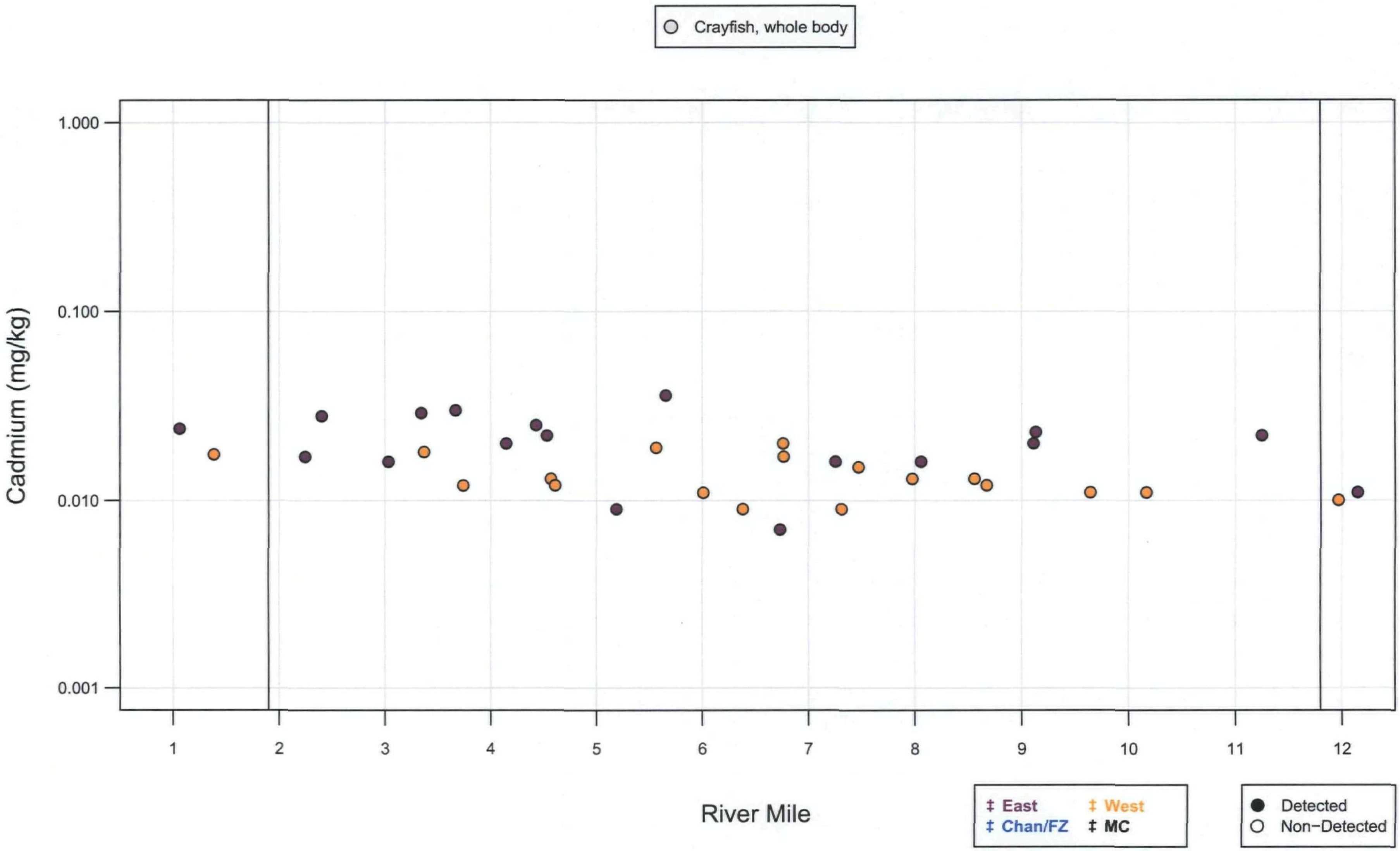

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Figure D5.2−16g
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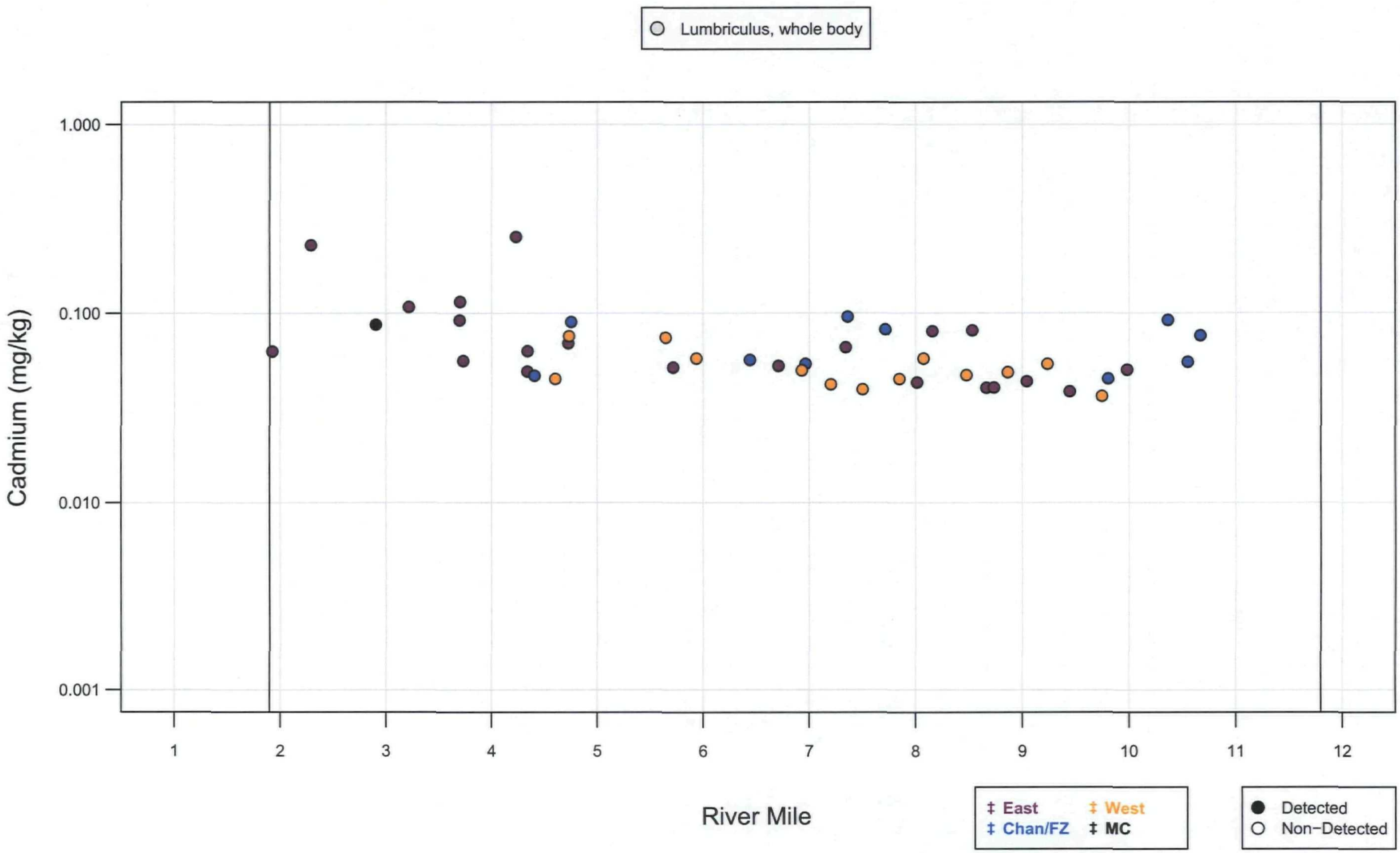

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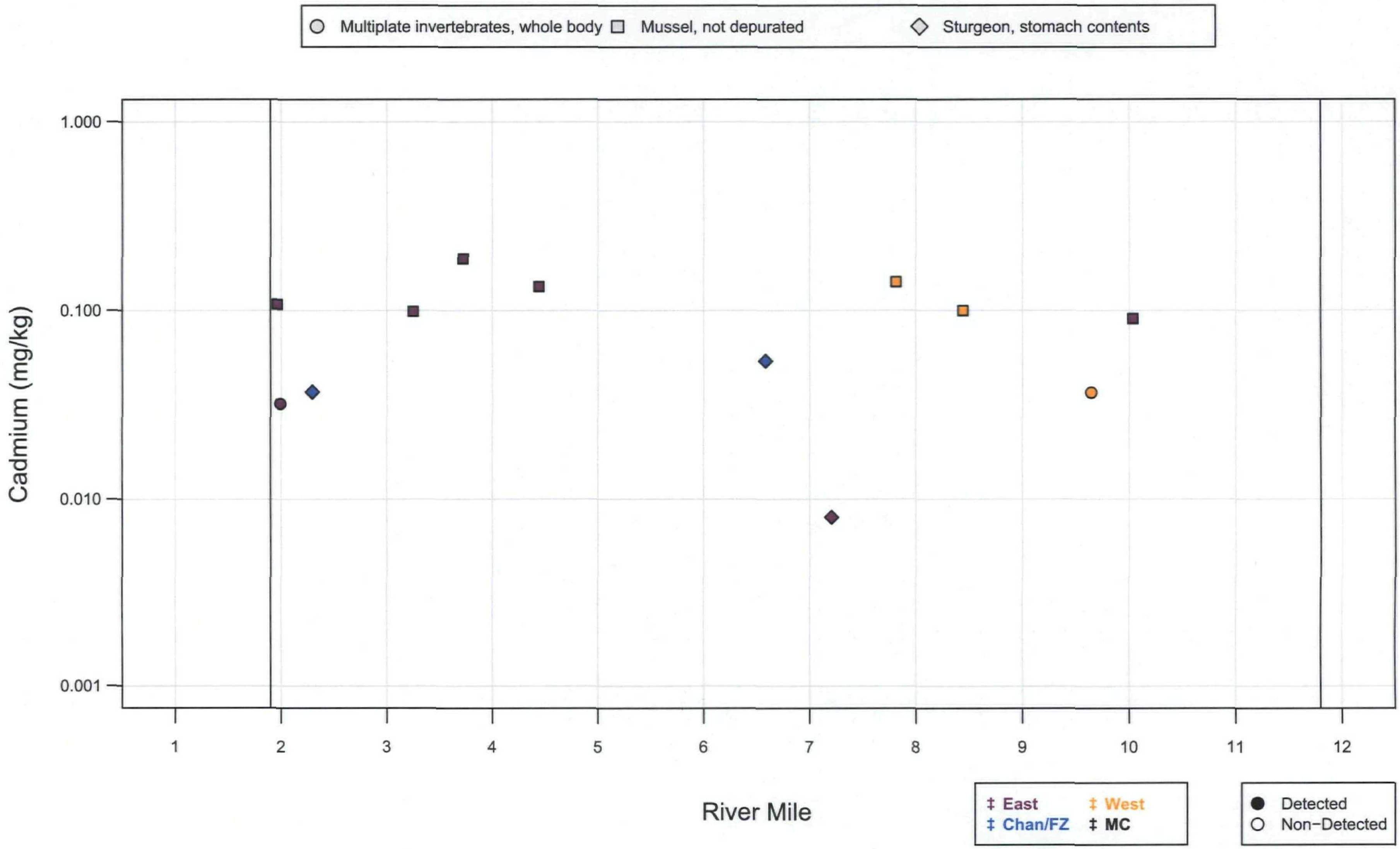

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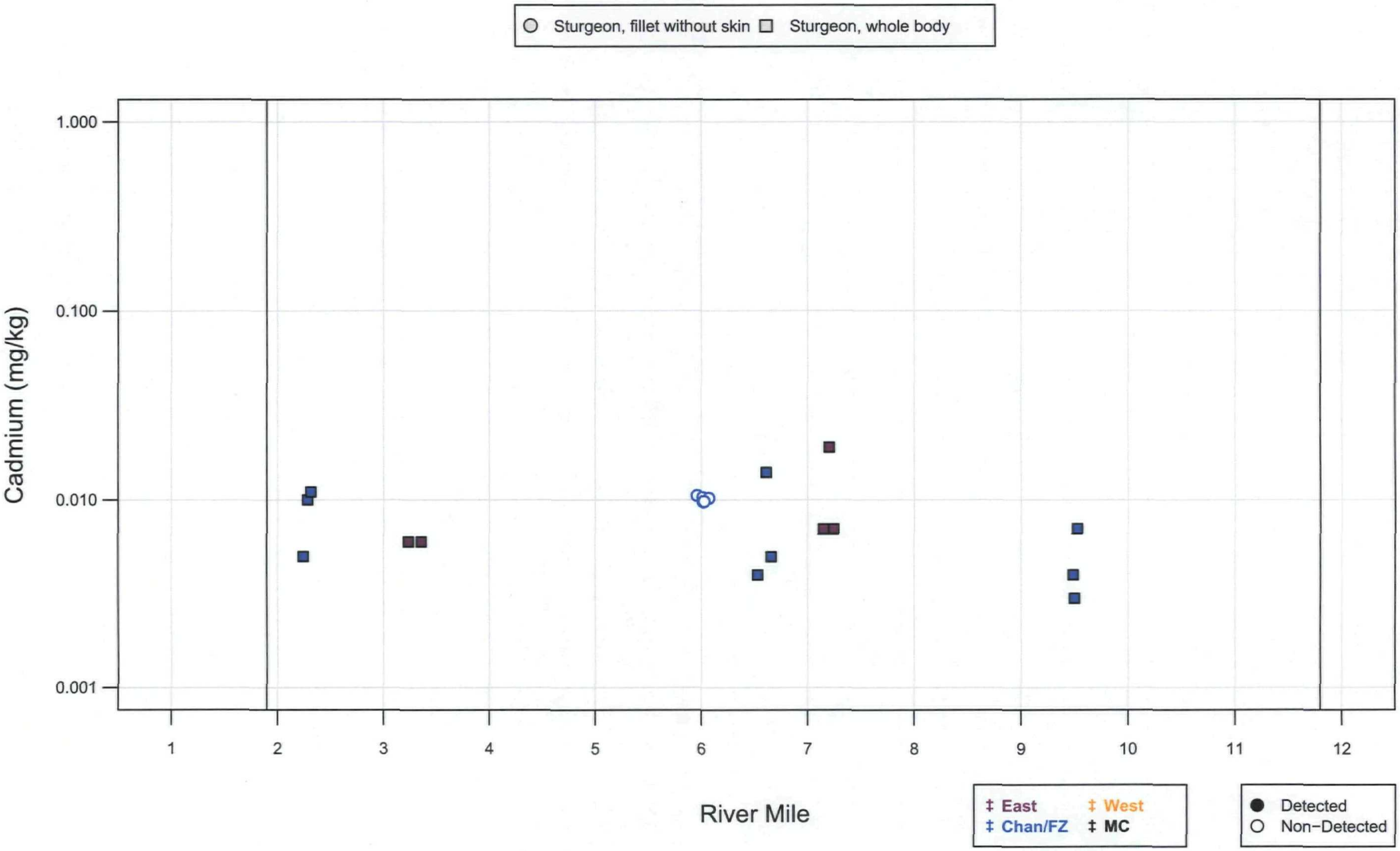

Figure D5.2-16j

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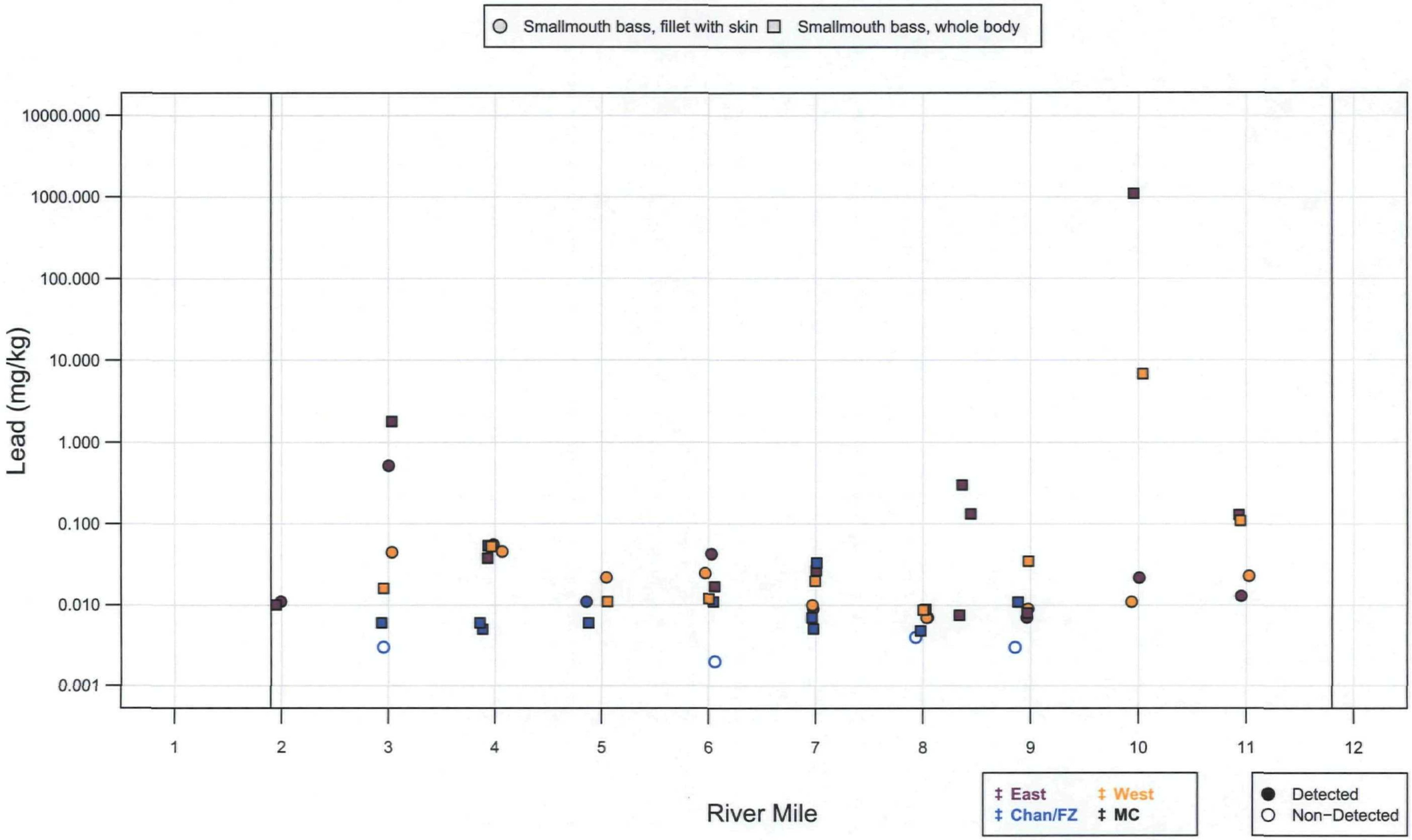

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Figure D5.2-17a

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Lead in
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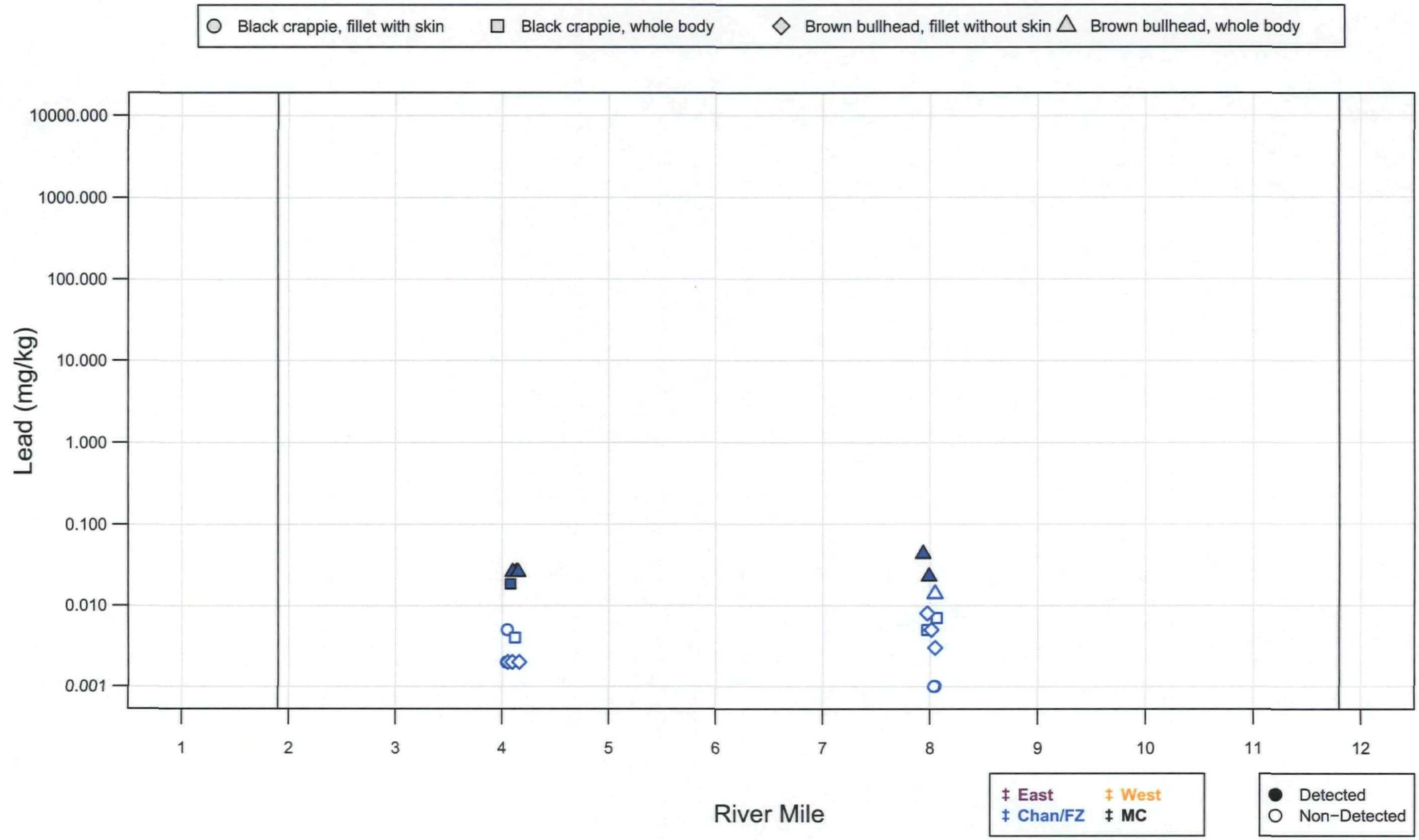

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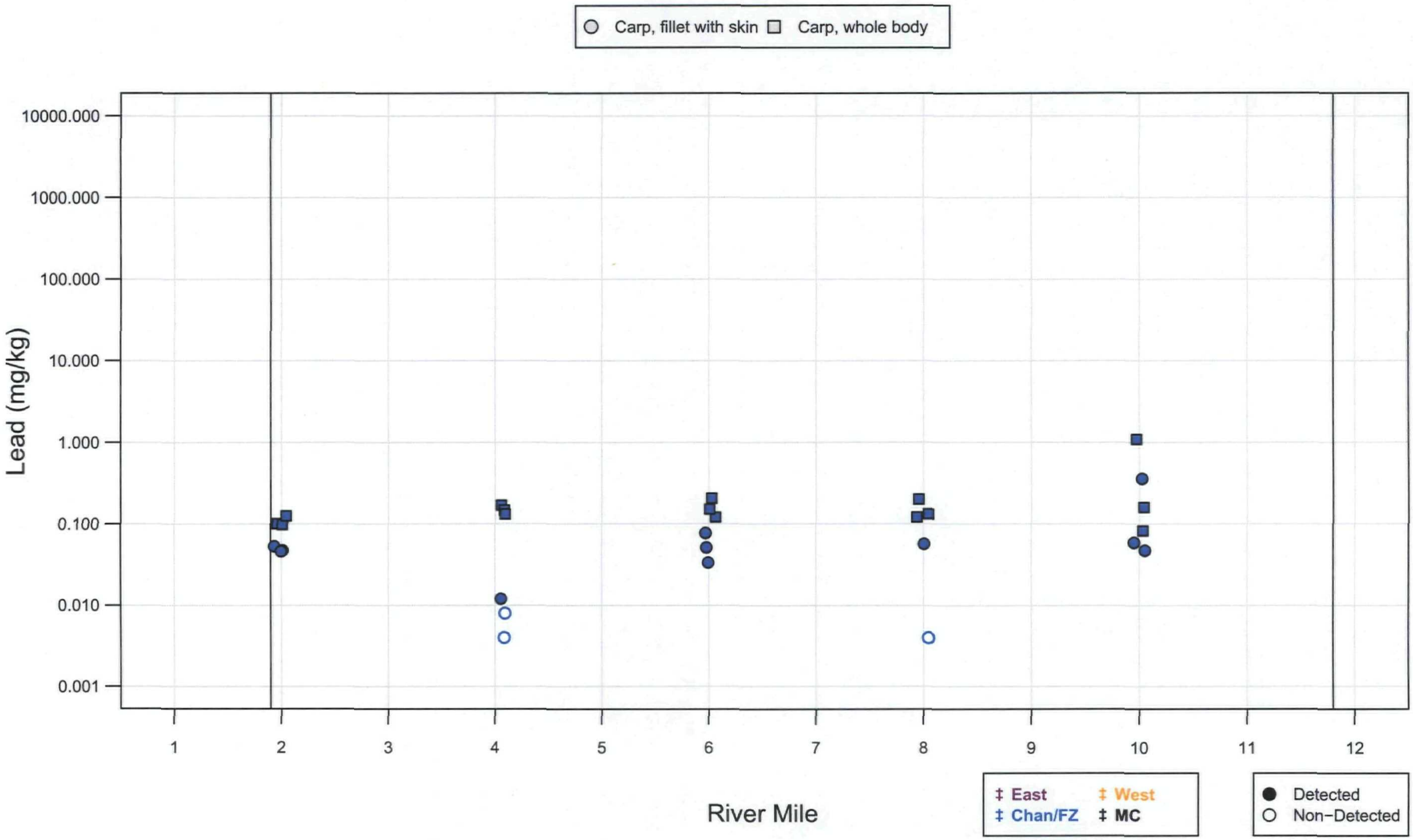

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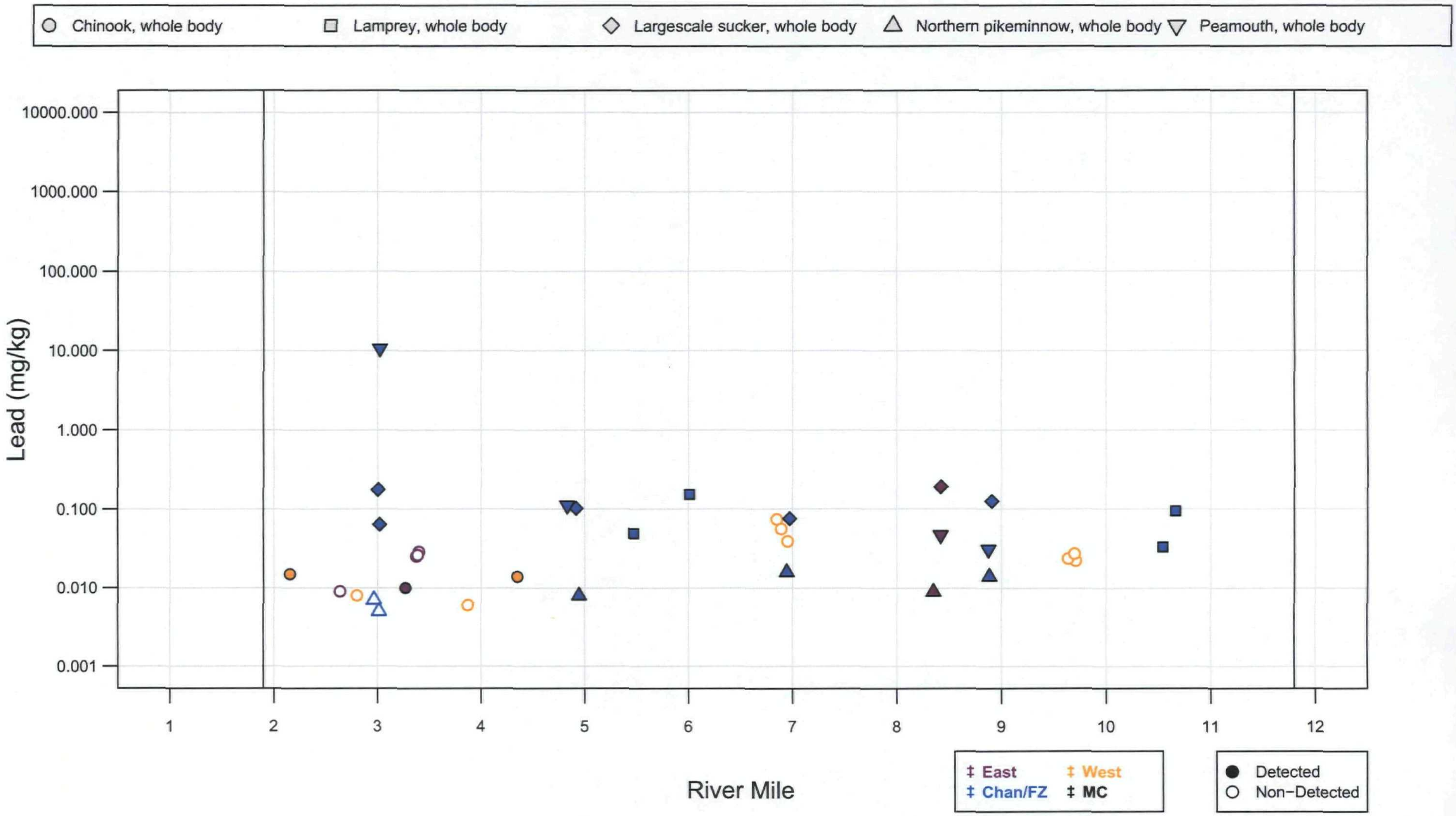

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Tissue Samples by River Mile, RM 0.8-12.2

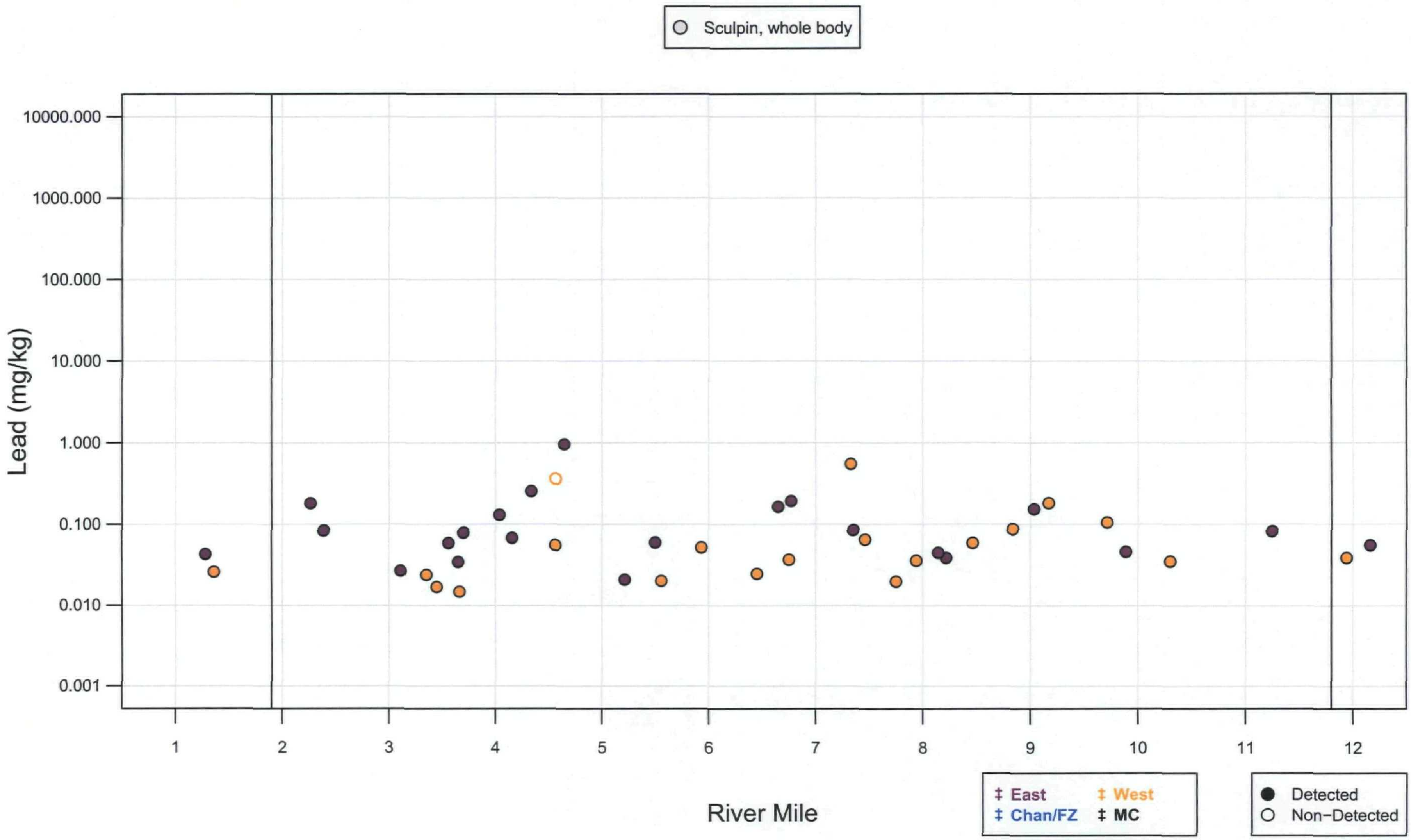

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Figure D5.2-17e

Portland Harbor RI/FS
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Scatter Plot of Lead in
Tissue Samples by River Mile, RM 0.8-12.2

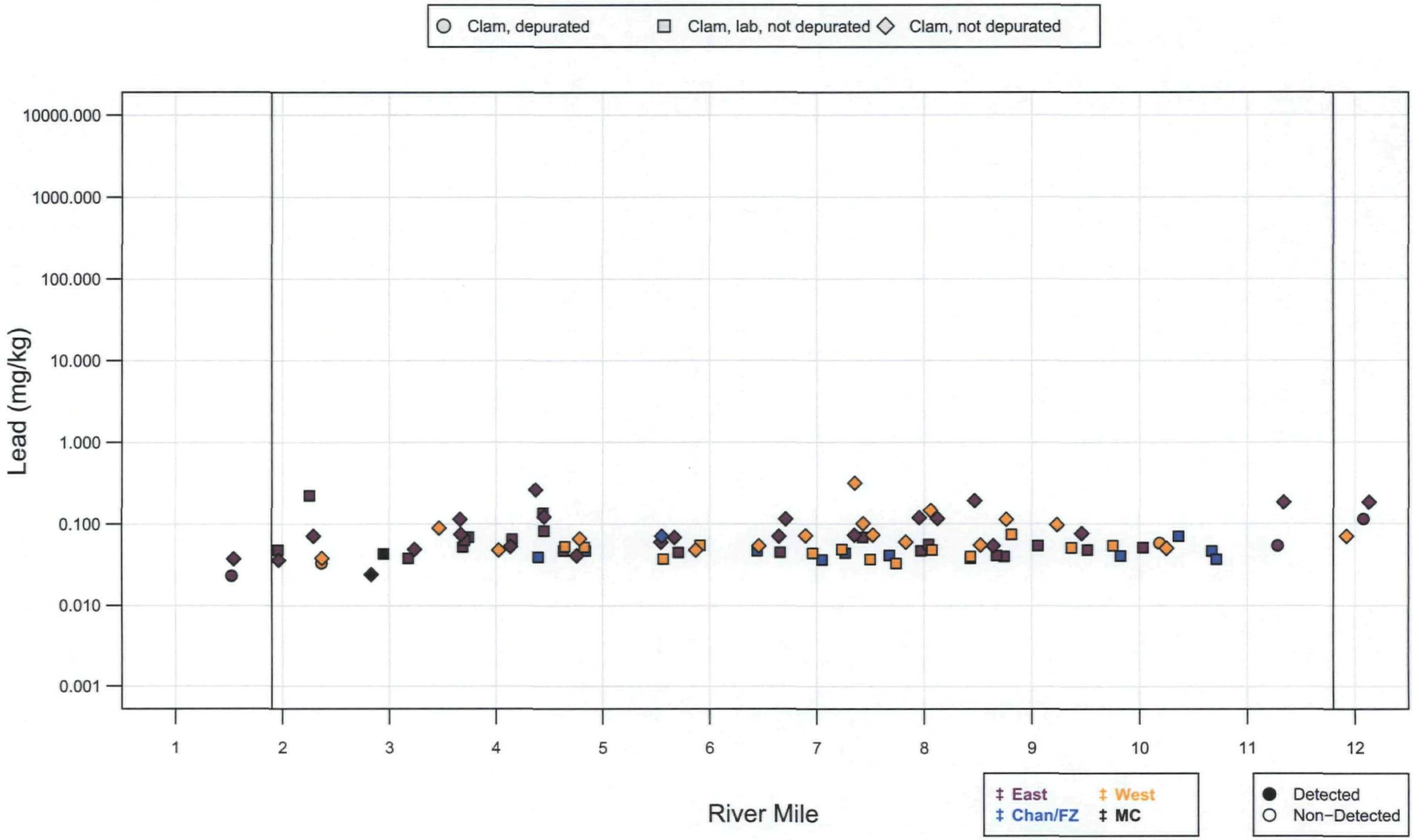

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Figure D5.2-17f
Portland Harbor RI/FS
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Tissue Samples by River Mile, RM 0.8-12.2

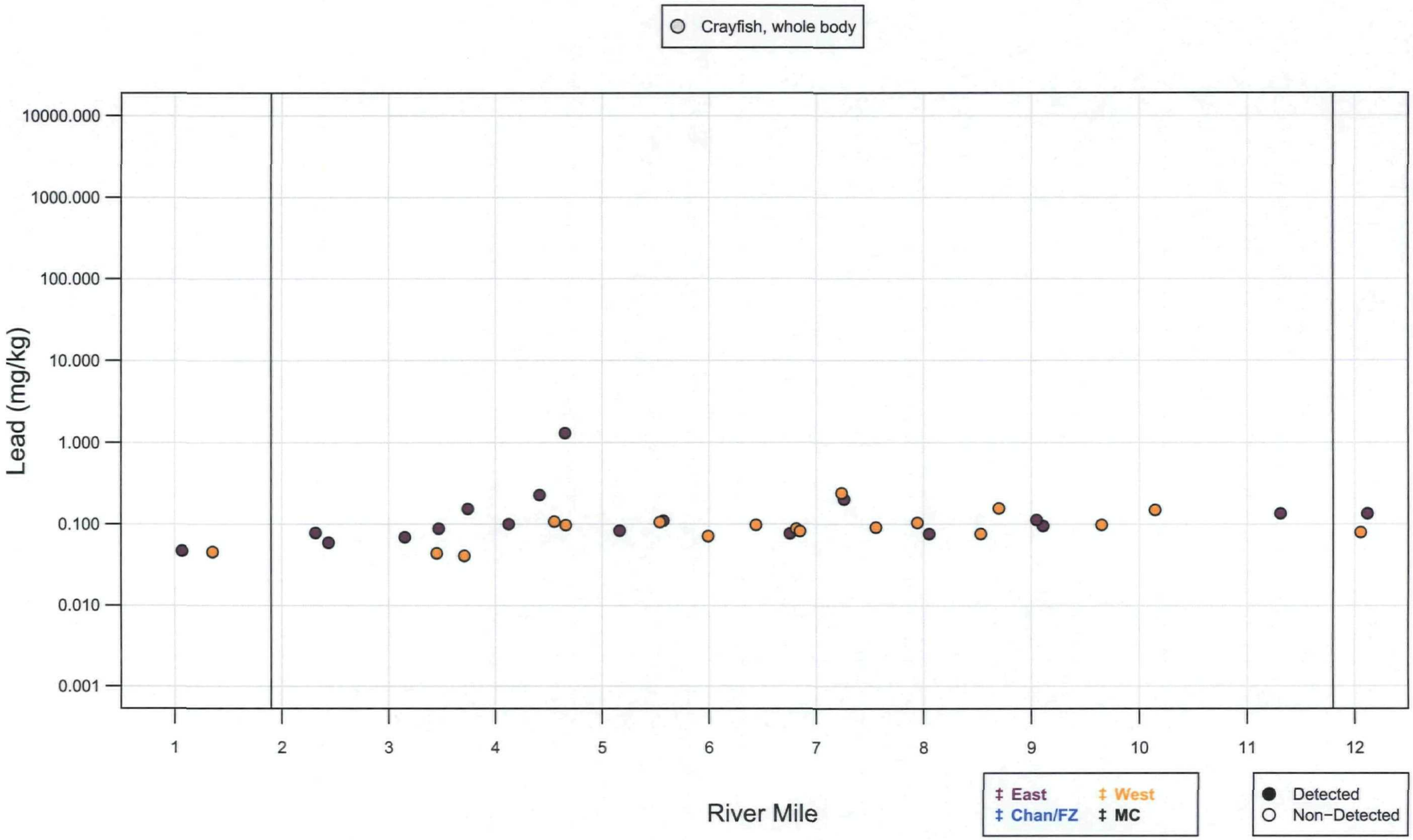

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Figure D5.2-17g

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Draft Remedial Investigation Report
Scatter Plot of Lead in
Tissue Samples by River Mile, RM 0.8-12.2

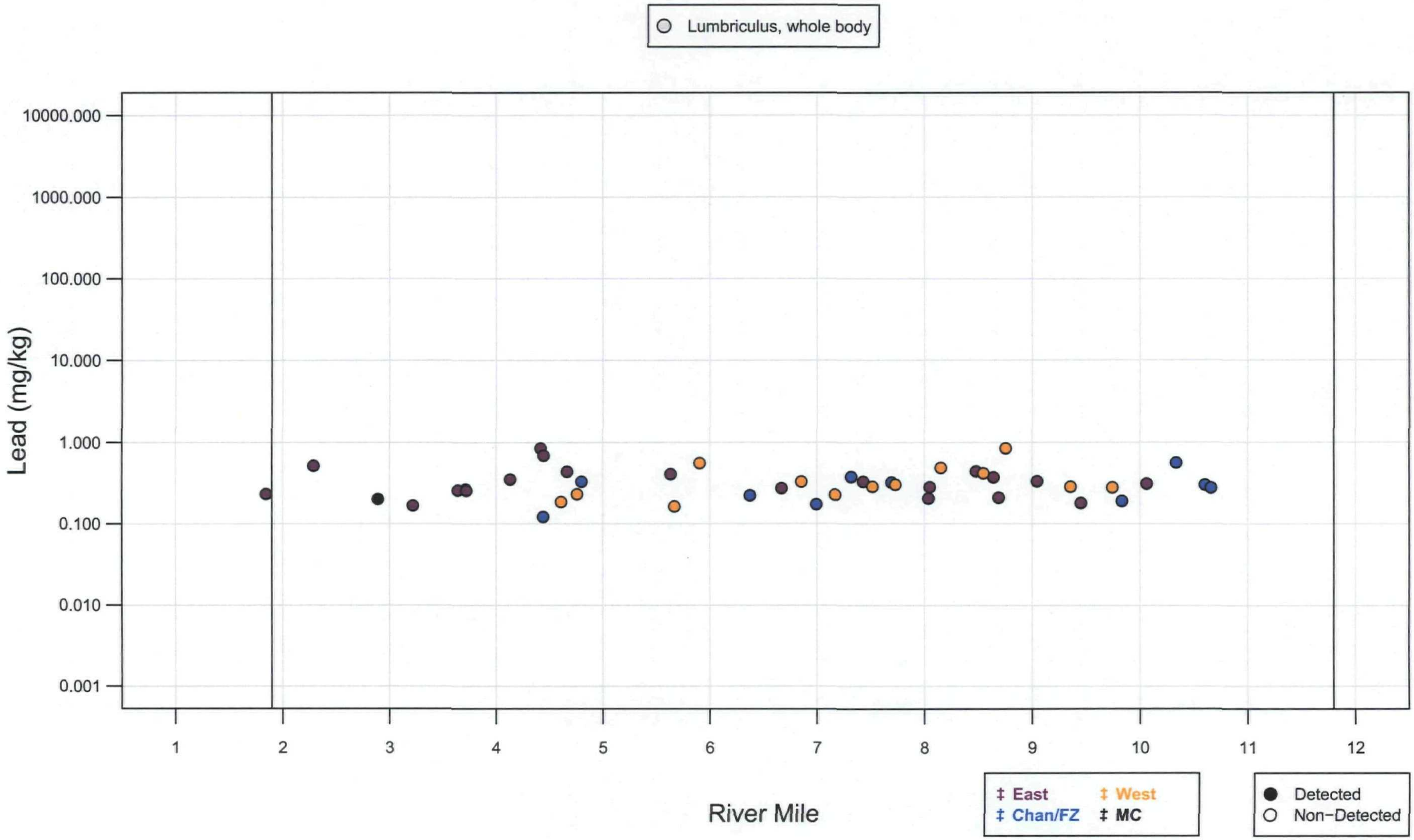

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Figure D5.2-17h

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Lead in
Tissue Samples by River Mile, RM 0.8-12.2

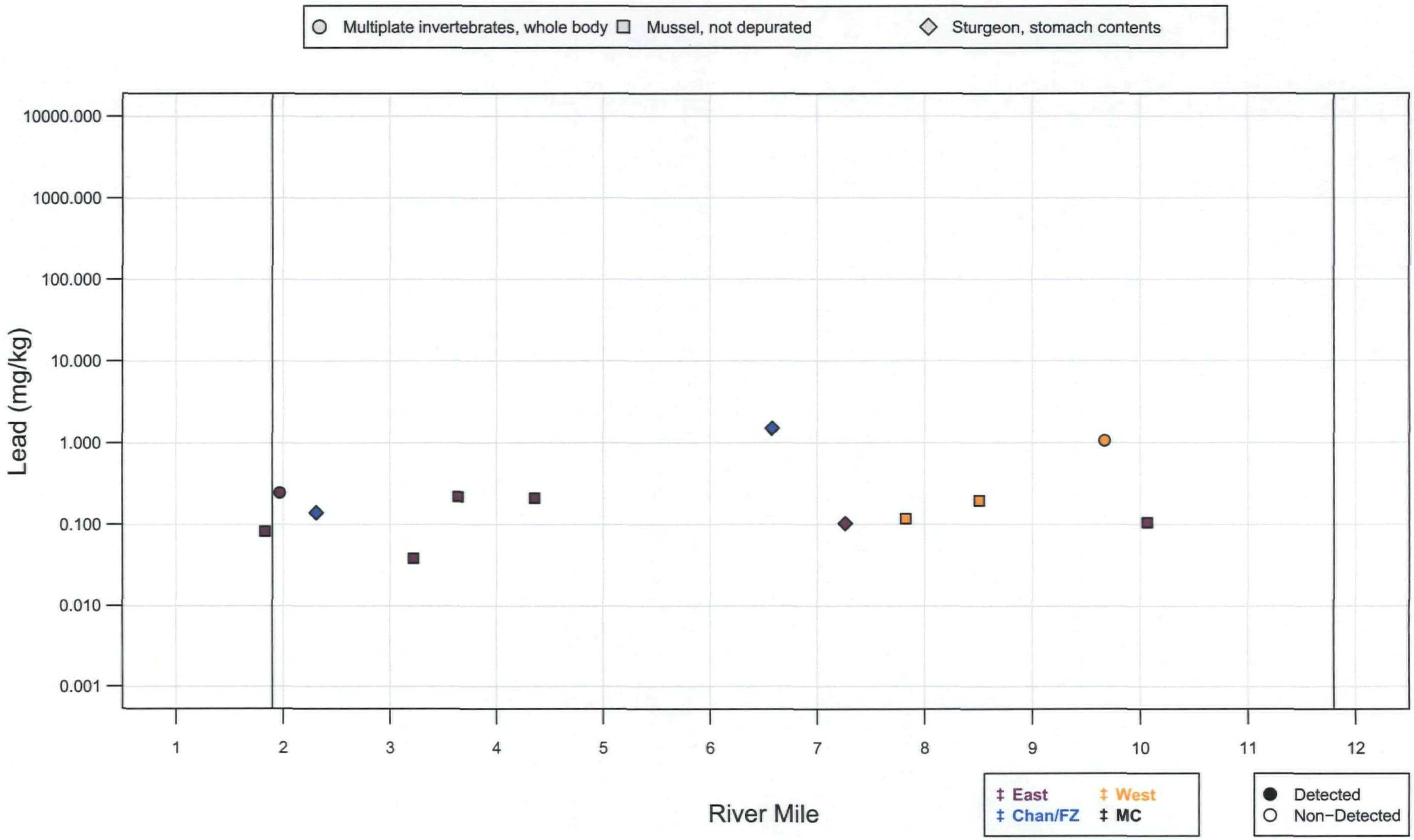

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Figure D5.2−17i
Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Lead in
Tissue Samples by River Mile, RM 0.8−12.2

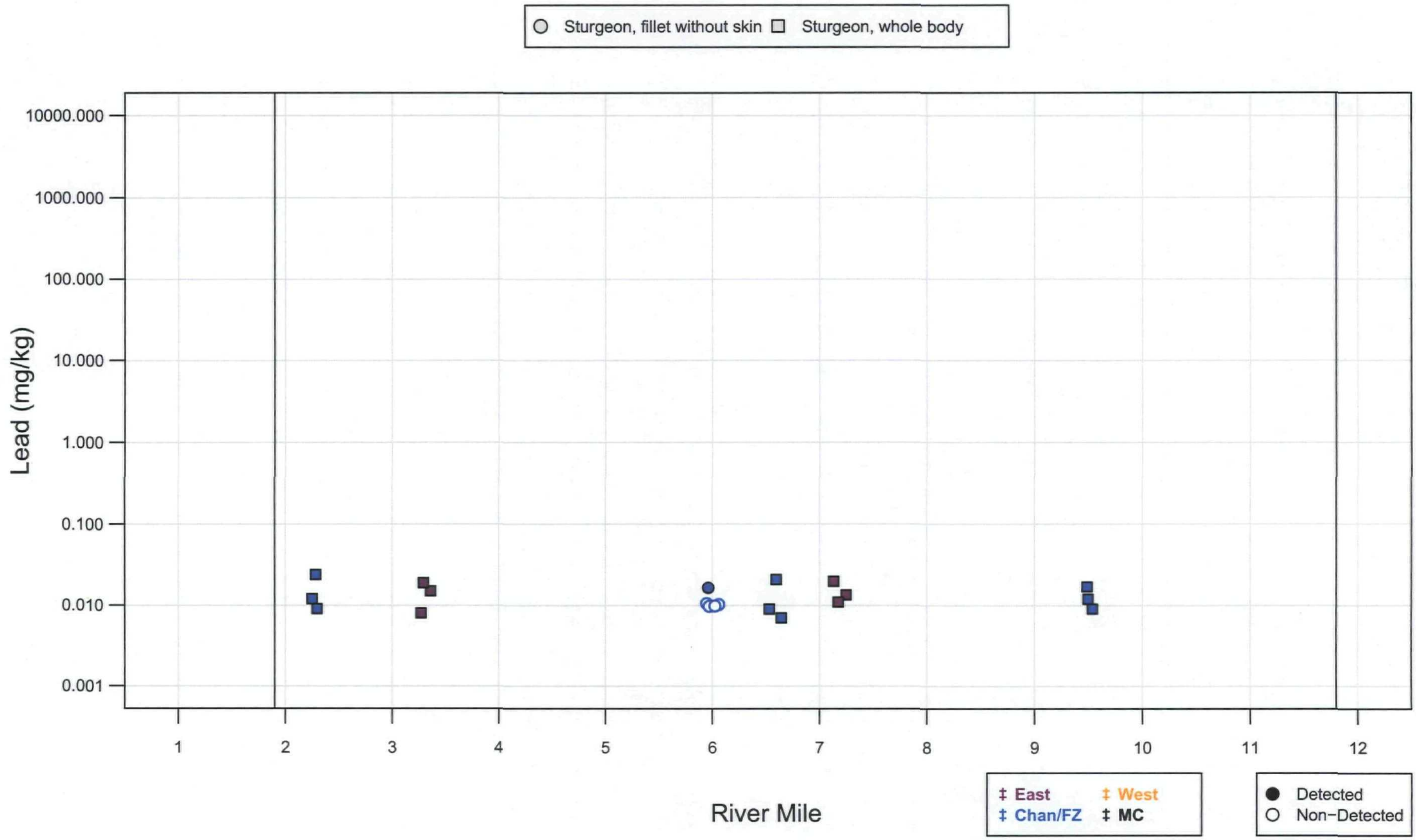

Figure D5.2-17j

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Lead in
Tissue Samples by River Mile, RM 0.8–12.2

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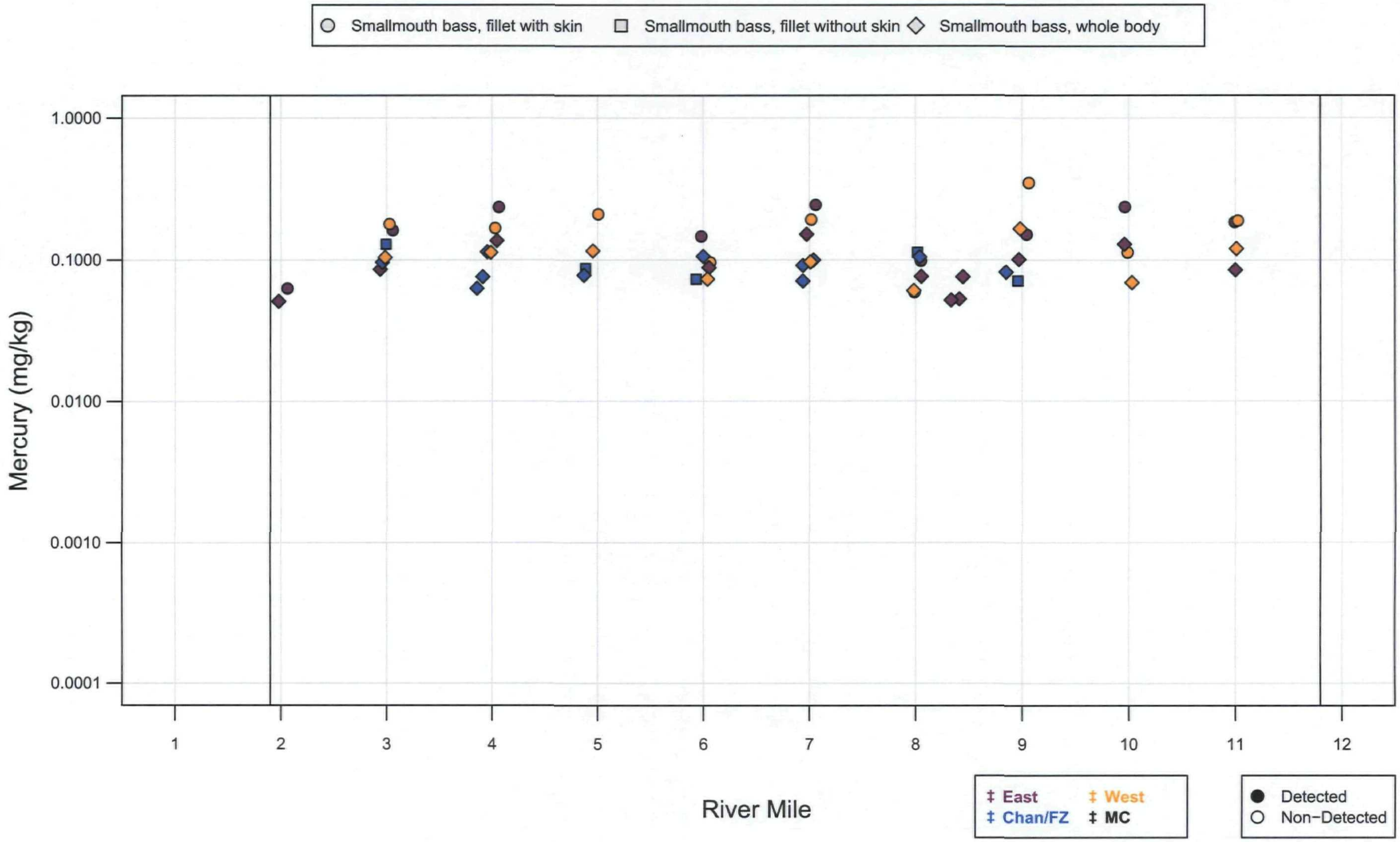

Figure D5.2-18a

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Mercury in
Tissue Samples by River Mile, RM 0.8-12.2

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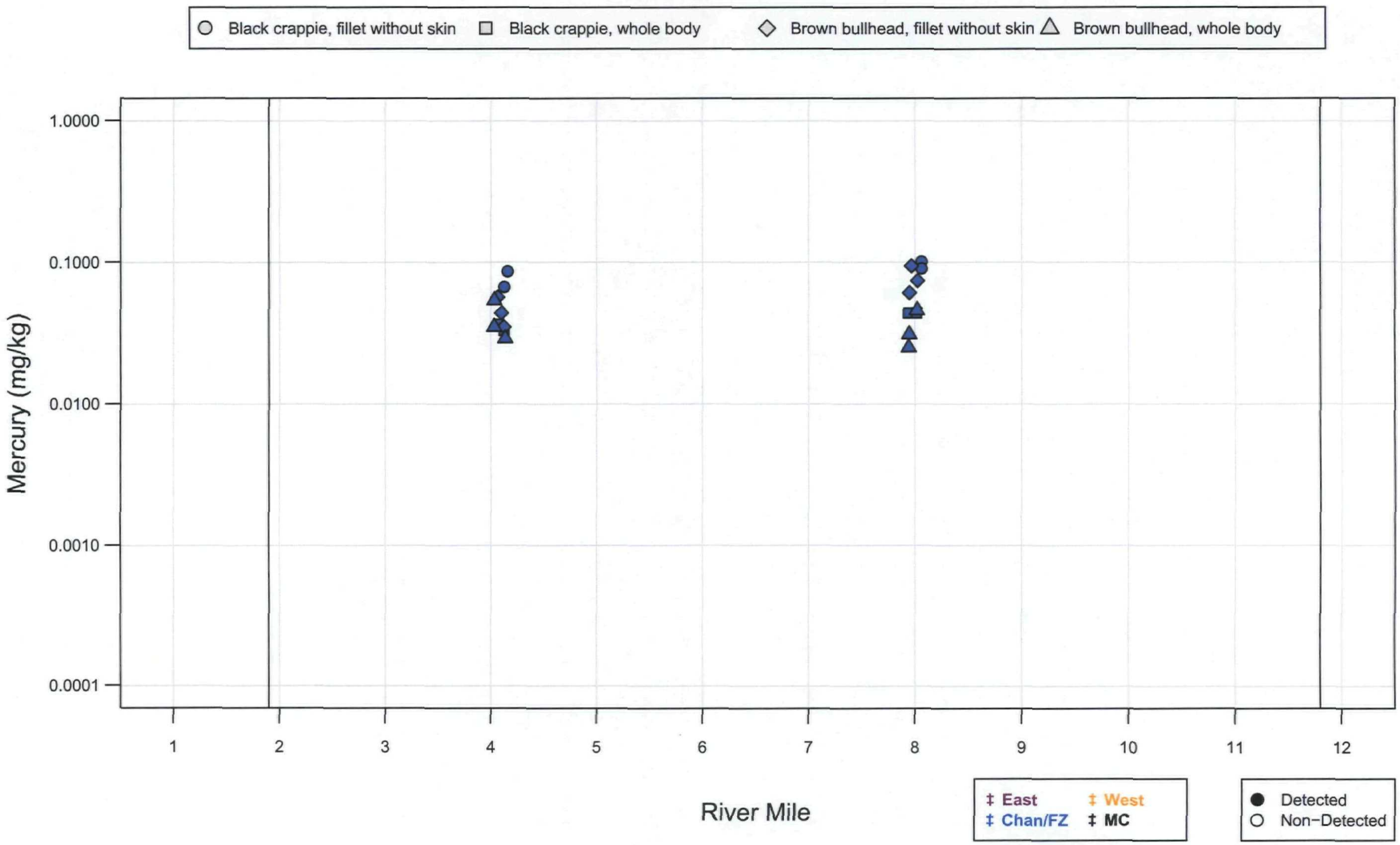

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Figure D5.2-18b

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Mercury in
Tissue Samples by River Mile, RM 0.8-12.2

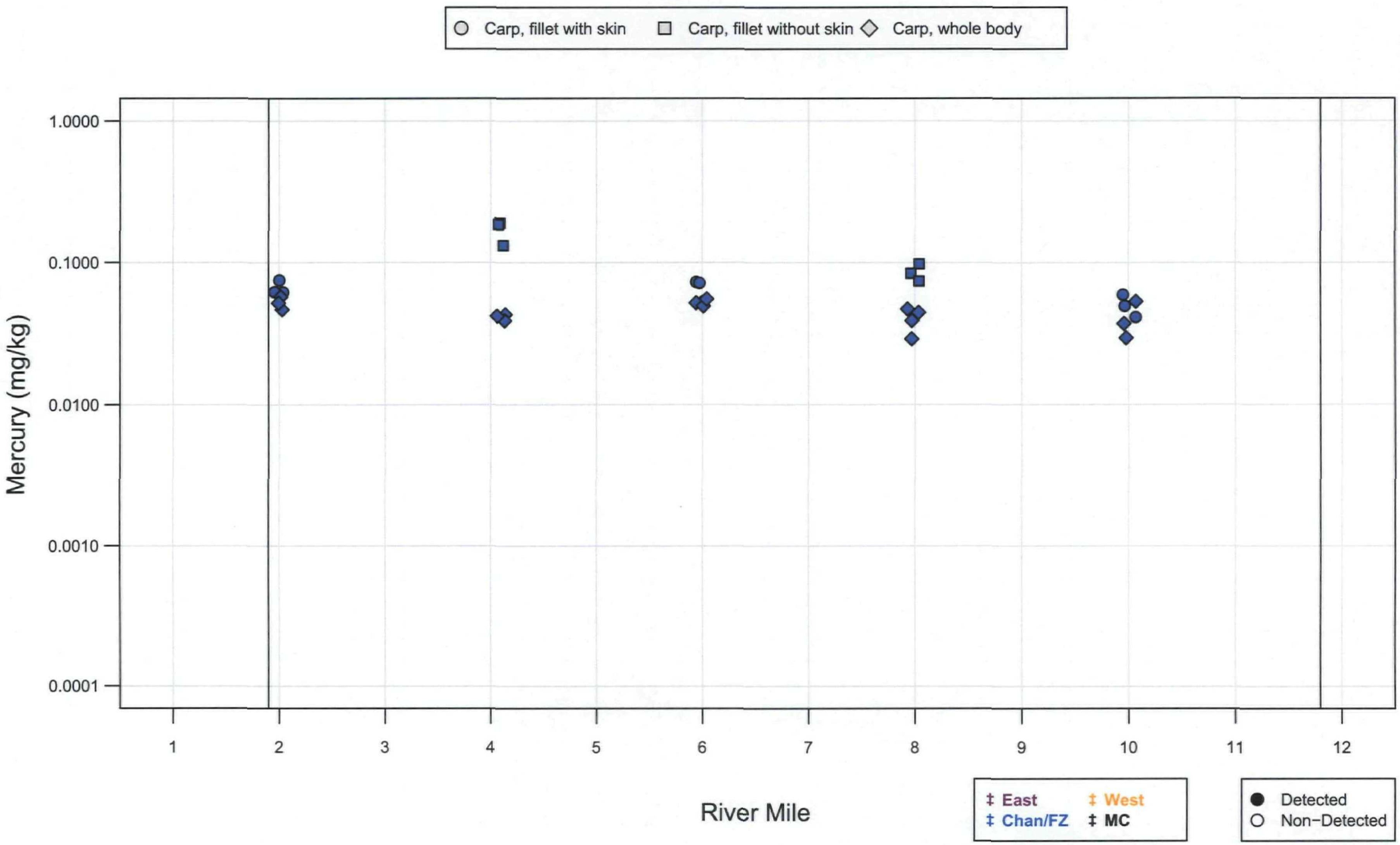

Figure D5.2-18c

Portland Harbor RI/FS
Draft Remedial Investigation Report
Scatter Plot of Mercury in
Tissue Samples by River Mile, RM 0.8-12.2

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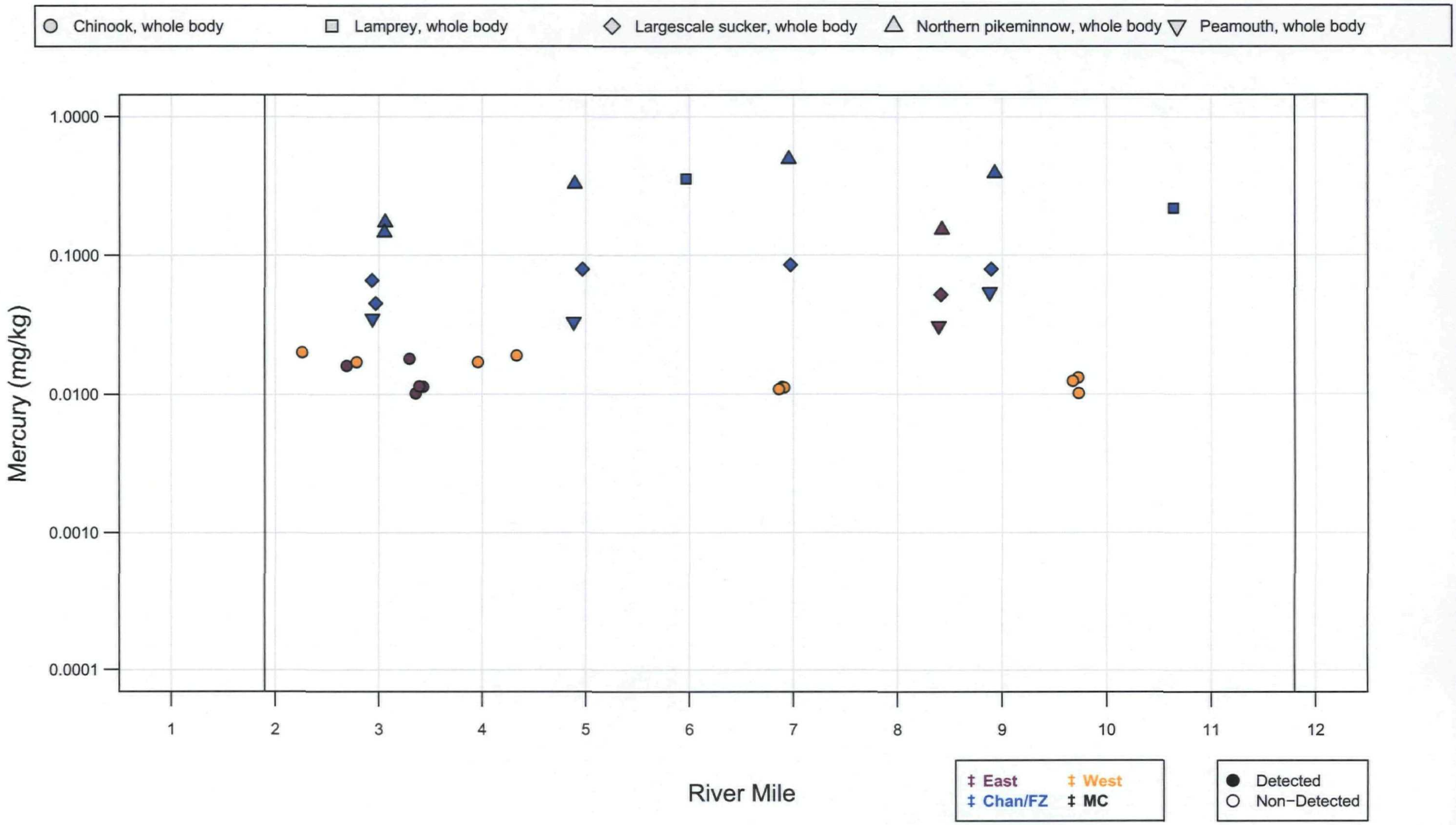

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Figure D5.2−18d

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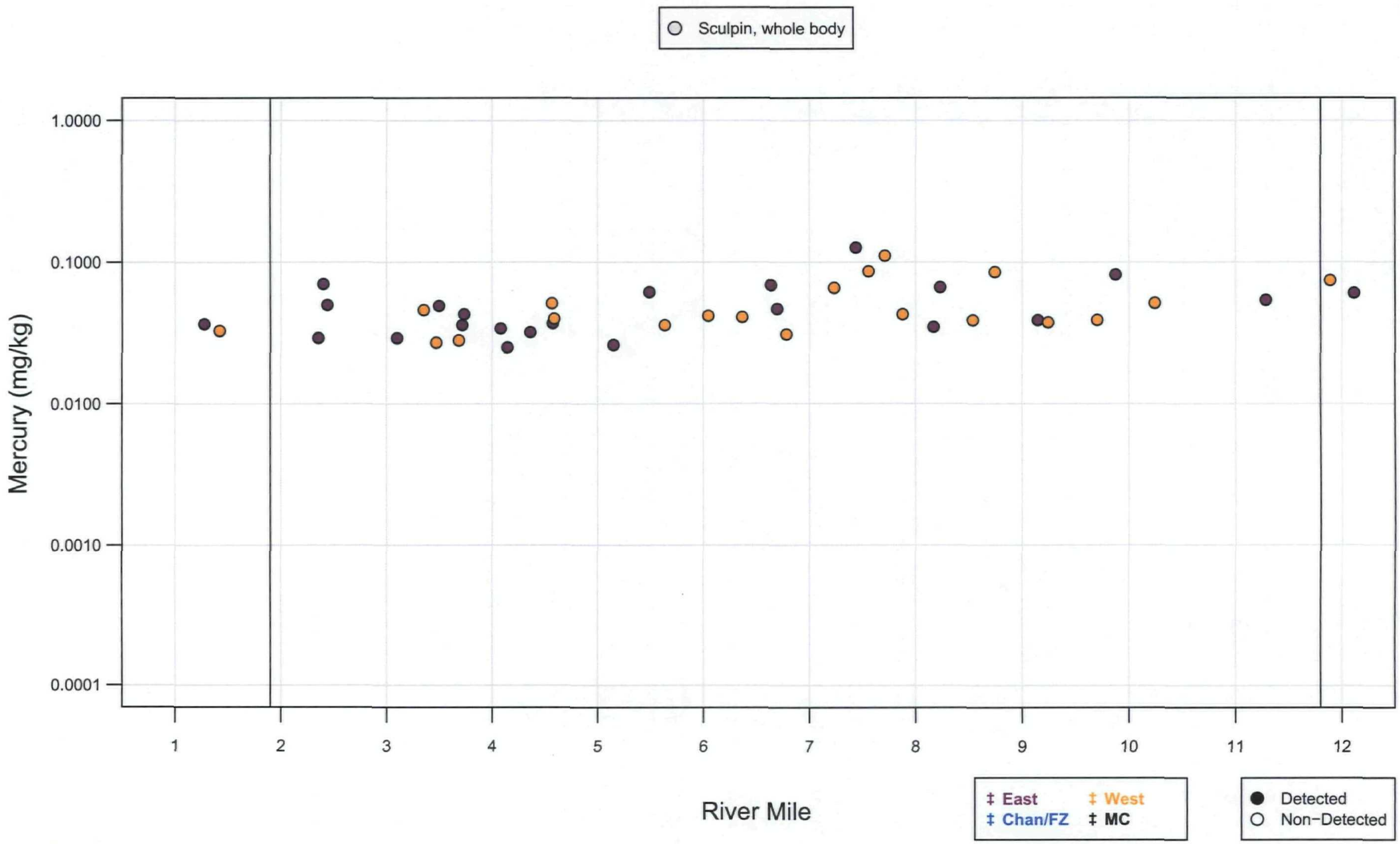

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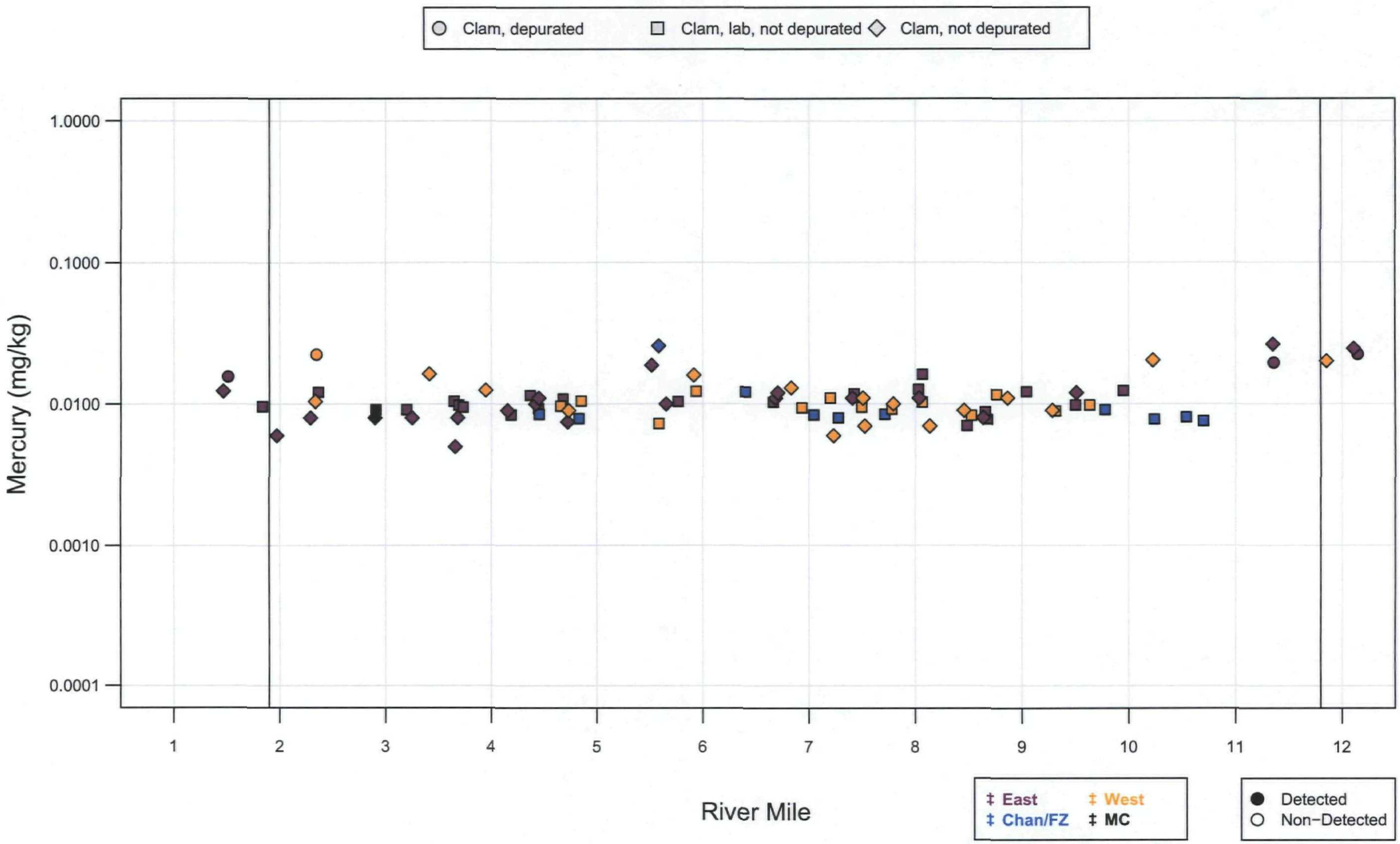

Figure D5.2-18f

Portland Harbor RI/FS
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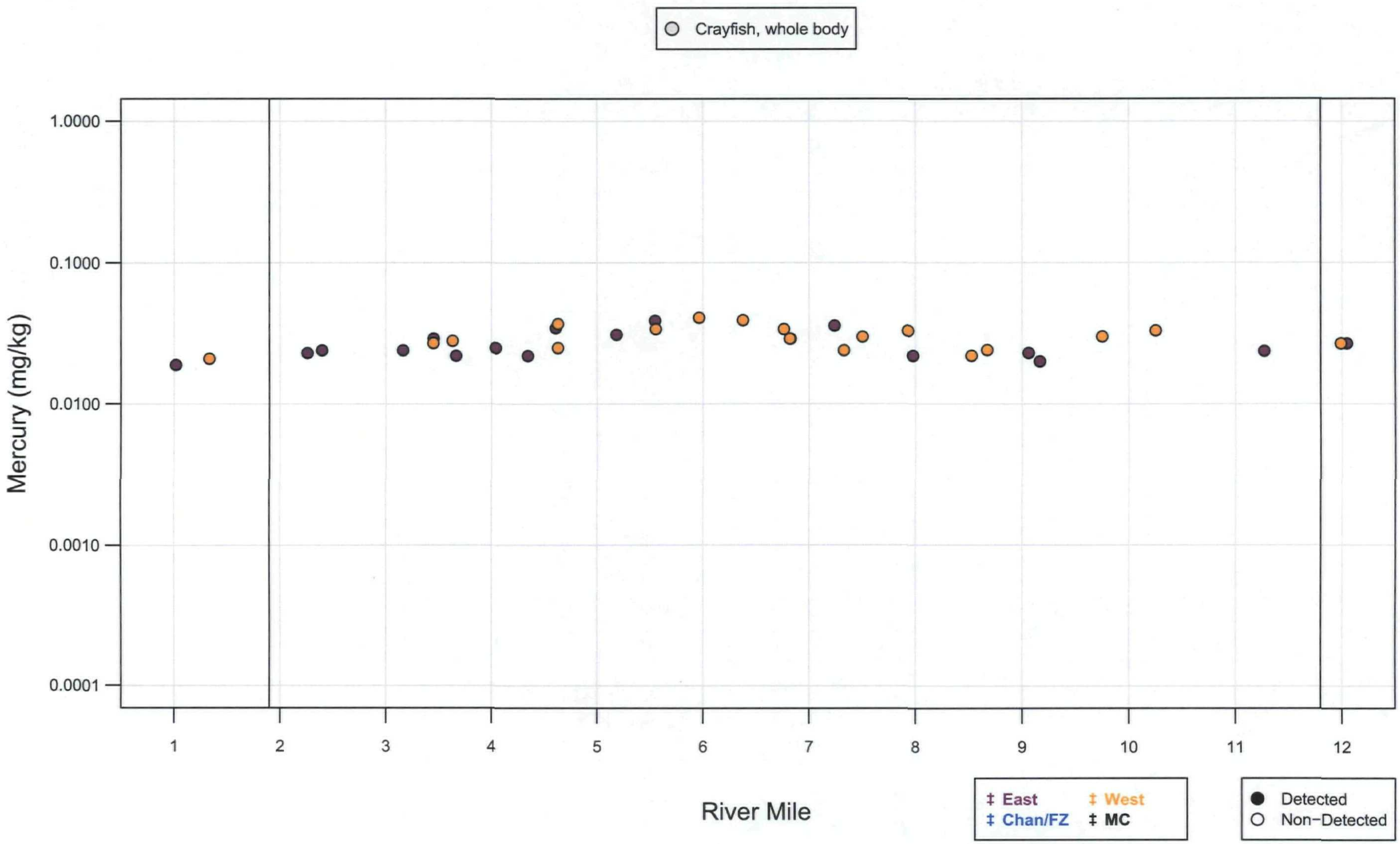

Figure D5.2-18g

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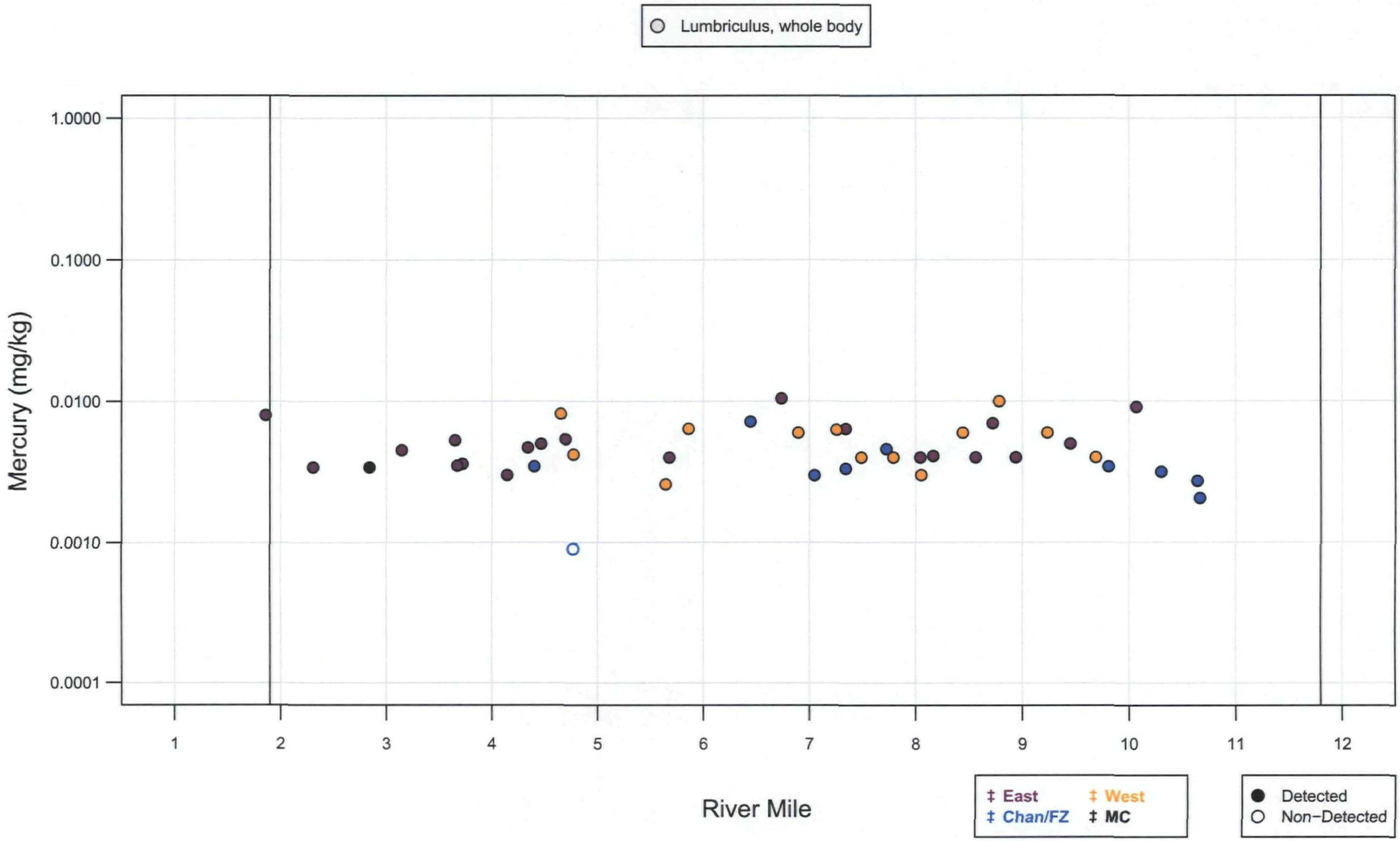

Figure D5.2−18h

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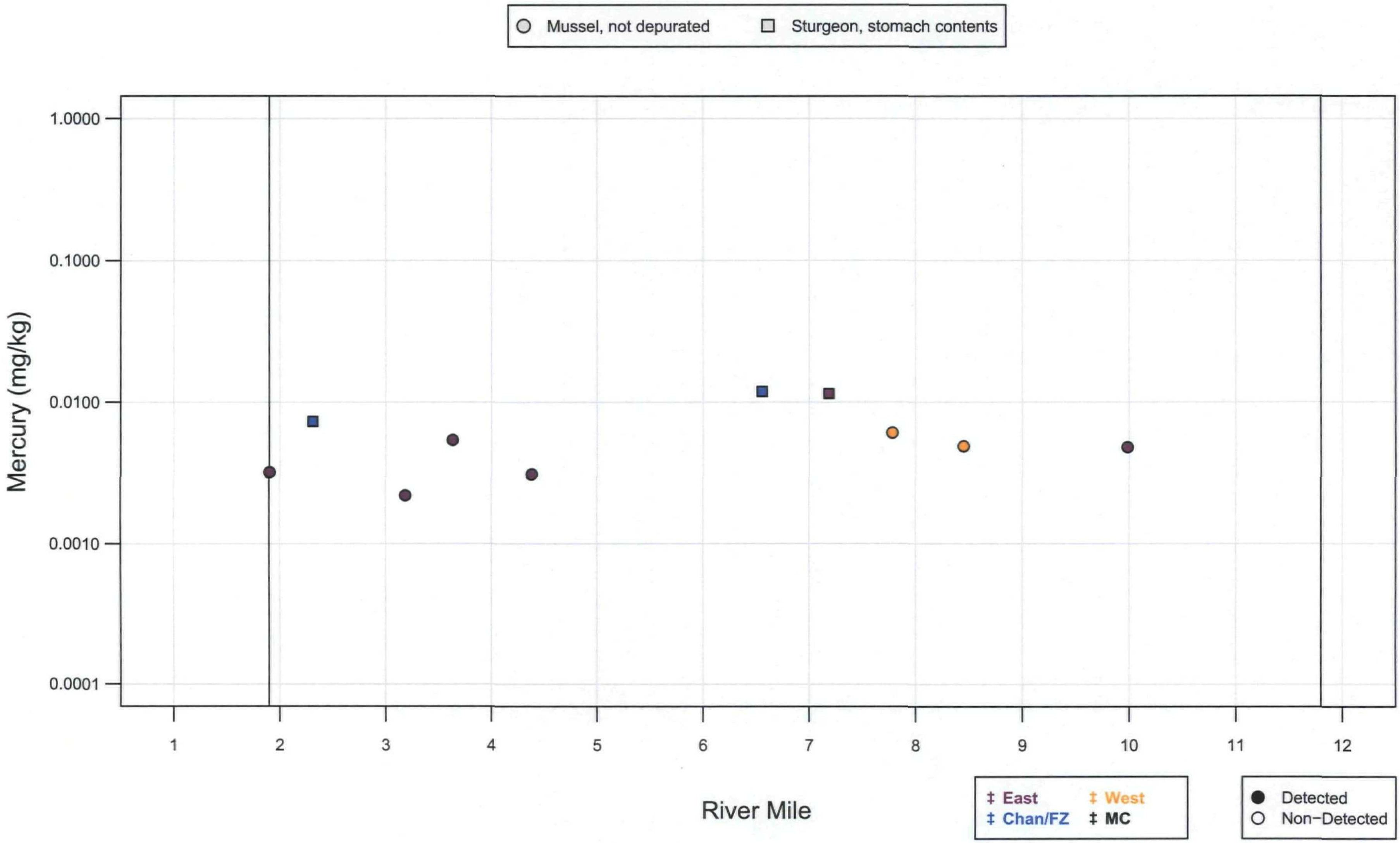

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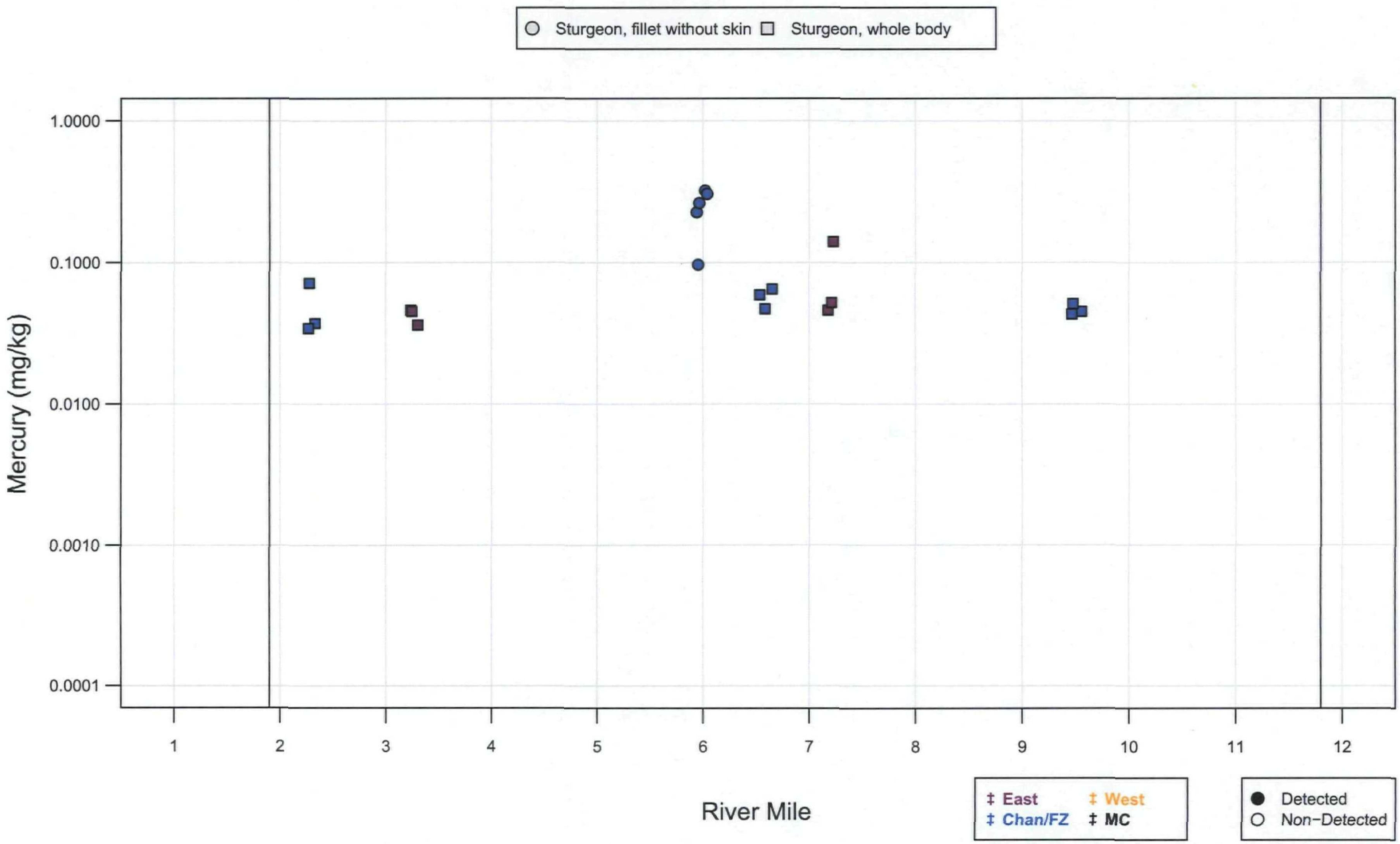

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Figure D5.2−18j
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Scatter Plot of Mercury in
Tissue Samples by River Mile, RM 0.8−12.2

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PORTLAND HARBOR RI/FS

REMEDIAL INVESTIGATION REPORT

APPENDIX D6

UPSTREAM-DOWNSTREAM SUMMARY STATISTICS AND RADIOISOTOPE TECHNICAL MEMORANDUM

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October 27, 2009

Appendix D6.1

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PORTLAND HARBOR RI/FS

REMEDIAL INVESTIGATION REPORT

APPENDIX D6.1
SUMMARY STATISTICS FOR ALL ANALYTES (ON CD)

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October 27, 2009

Appendix D6.2

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PORTLAND HARBOR RI/FS

REMEDIAL INVESTIGATION REPORT

APPENDIX D6.2
ROUND 3A MONITORED NATURAL RECOVERY AREA RADIOISOTOPE EVALUATION

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October 27, 2009

ANCHOR
ENVIRONMENTAL, L.L.C.

Anchor Environmental, L.L.C.
1423 3rd Avenue, Suite 300
Seattle, Washington 98101
Phone 206.287.9130
Fax 206.287.9131

Memorandum

To: Gene Revelas and Nick Varnum, Integral Consulting, Inc.

From: Ryan Barth and Carl Stivers, Anchor Environmental, L.L.C.

Date: August 6, 2007

Re: Round 3A Monitored Natural Recovery Area Radioisotope Evaluation - Portland Harbor Superfund Site

This technical memorandum presents an evaluation of the sediment core data collected from known depositional zones in the upstream portion of the Portland Harbor Superfund Site (Site) Study Area (i.e., river mile [RM] 2 to RM 11). This data was collected as described in the field sampling plan (FSP) prepared by Integral Consulting, Inc. (Integral) entitled *"Portland Harbor RI/FS Preliminary Upstream and Downstream Sediment Data Evaluation and Round 3A Field Sampling Plan for Upstream and Downstream Sediment Sampling"* (Integral 2006) to support the Site remedial investigation and feasibility study (RI/FS). Specifically, as described in the FSP (Integral 2006), the primary objectives of the core data collection were to assist with the development of estimates of naturally occurring background concentrations and anthropogenic concentrations (consistent with EPA policy) in the Lower Willamette River (LWR) sediments in the upstream extents of the Study Area (i.e., between RM 9 and RM 11). An estimate of upstream contaminant loading is needed for the FS to assess the potential for recontamination and/or natural recovery of surface sediments at the Site. An estimate of background concentrations is needed to support the human health and ecological risk characterizations and to support the identification of cleanup goals in the FS. The upstream data will also be used by EPA to support the establishment of an upstream Site boundary.

Background

As described in the *Portland Harbor RI/FS Round 3A Upstream & Downstream Sediment Field Sampling Report – Draft* prepared by Integral dated April, 9, 2007, co-located cores were collected from the target stations shown in Figure 1 for radioisotope and chemistry analysis. Each of the target areas were shown to be depositional areas based on the evaluation of bathymetric change data from 2002 to 2004. Station RC483 is located at approximately RM 9.6, in the center of the large shoaling area located in the western half of the channel between RM 9 and 10. This area is within a broad gently sloping portion of the riverbed at a depth of approximately -27 feet (North American Vertical Datum [NAVD] 88). Stations RC01 and RC02 are located in former dredge pits in the western portion of the channel at RM 10.5 and RM 10.9, respectively. The pits were dredged to an elevation of approximately -75 feet NAVD88 in approximately 1988[1]. Station RC01 is located in the downstream dredge pit depression and has a current mudline of -59 feet (NAVD88). Station RC02 is located in the upstream dredge pit depression and has a current mudline elevation of -51 feet NAVD88. The identified depth of accumulation in each of the dredge pit depressions (i.e., 16 feet at RC01 and 24 feet at RC02) confirmed that these areas act as natural sediment traps for sediment entering the Study Area from upstream.

At each station, a single core was collected for radioisotope analysis of Beryllium-7 (^{7}Be), Cesium-137 (^{137}Cs), and Lead-210 (^{210}Pb). Once each radioisotope core was collected, a second core was collected adjacent to the initial station location in undisturbed sediment for testing of the following standard suite of chemicals of interest (i.e., metals, semivolatile organic compounds [SVOCs], polychlorinated biphenyl [PCB] aroclors, and chlorinated pesticides) as well as dioxins and total petroleum hydrocarbons (TPHs). Each core was sampled in 2 centimeter (cm) increments and every fourth interval was analyzed (regardless of changes in stratigraphy) for the radioisotope analytes. Each 30-cm (i.e., 1-foot) interval of the co-located core was sampled for the suite of chemical parameters with an archive sample collected from each 7.5-cm interval. This memorandum does not provide further discussion of the chemical results.

Radioisotope Evaluation Methodology

The mixing layer at each station can be evaluated using ^{7}Be data. This isotope is a naturally occurring isotope continually produced by cosmic ray bombardment of oxygen and nitrogen in the atmosphere (Brigham et. al. 2001). Given the half-life of this isotope is relatively short (53 days), detected activities indicate recent mixing has occurred. Therefore, the approximate mixing layer depth at each monitoring station can be obtained directly from the activity profiles where ^{7}Be is detected.

[1] This data was approximated based on review of the February 3, 1988 U.S. Army Corps of Engineers condition survey map. It was assumed that the pits were dredged the year the condition survey was performed.

Activity plots for ^{137}Cs and ^{210}Pb can be evaluated in tandem to attempt to calculate the net sedimentation rate and to date the sediments with depth. The ^{137}Cs profiles can be evaluated to assign calendar dates to the sediment column. This isotope is a result of thermonuclear reactions and was introduced into the atmosphere during the early days of nuclear testing (Brigham et. al. 2001). In the United States, the first appearance of the isotope was in 1954 and the activity peaked in 1963 (Hewitt 2000). There was also a relatively small-scale release of atmospheric ^{137}Cs in 1986 from the explosion that occurred at the Chernobyl nuclear power plant. Thus if ^{137}Cs is detected at a given depth, the date is interpreted to be 1954 or afterward and the peak in the profile can be assigned to 1963.

Lead-210 can be used to date sediments based on its isotopic decay. ^{210}Pb is a naturally occurring isotope that is formed as part of the Uranium-238 (^{238}Ur) decay of the earth's crust soils (Brigham et. al. 2001). Radon-222 (^{222}Ra) is an intermediate daughter isotope of ^{226}Ra and escapes into the atmosphere in the gaseous form. The ^{222}Ra further rapidly decays through a series of very short half-life isotopes to ^{210}Pb. This process produces excess ^{210}Pb in the atmosphere. This highly reactive isotope of lead is rapidly adsorbed to or incorporated on particulate material. Subsequent precipitation of this material from the atmosphere to the hydrosphere produces excess ^{210}Pb over ^{210}Pb in equilibrium with ambient ^{226}Ra already in sediments. It is the excess ^{210}Pb, which is calculated as the measured ^{210}Pb activity minus the sum of the measured ^{222}Ra activity and measured background ^{210}Pb activity, which can be used to date the sediments with depth.

In order to successfully use the ^{210}Pb radioisotope data to approximate the net sedimentation rate and/or sediment age with depth, it was assumed that the ^{210}Pb flux remains constant over time (i.e., Constant Rate of Supply [CRS] Model). This model can be applied to most sedimentary systems although variable deposition can decrease the accuracy of this model. It was also assumed that there is no post-depositional migration of the radionuclide and the activity of the supported ^{210}Pb supported by the ^{222}Ra in the sediments is independent of depth (Robbins and Edgington 1975; Hewitt 2000; Ciavola et al. 2002). In riverine environments, the ^{210}Pb flux can be variable (e.g., related to high flow events which might deposit more material or scour previously deposited material) and thus additional weight of evidence information was incorporated into the data evaluation process (see below) to ensure the radioisotope evaluation considered potential variations in the deposition rate, sediment physical characteristics, and/or erosional processes (i.e., propwash scour, dredging, flushing flows). In addition, sampling artifacts (e.g., mixing in the upper layers of the core during core processing) and sample holding times were also considered when analyzing the radioisotope trends.

Given radioactive decay is an exponential process, the logarithm of the ^{210}Pb activity should decrease linearly with depth (assuming conditions implied by the CRS Model) and the slope of the line can be used to calculate the sedimentation rate. As described in Hewitt (2000), when base 10 logarithms are used and the sediment depths are expressed in cm, the sedimentation rate in cm per year equals -0.01352 divided by the slope. Following this method, the ^{210}Pb activity data at each data was logarithmically transformed and the logarithmic ^{210}Pb activity versus depth was plotted. Due to the extremely low levels of excess ^{210}Pb activities observed at each station, the linear-regression best fit from the curve did not produce useful information or facilitate calculation of the net sedimentation rate (see results discussion below).

Given the Willamette River exhibits seasonal variable flow rates and deposition rates and is not a quiescent environment (i.e., such as a deep lake), additional site-specific information was examined to determine how the potential variability may have affected the applicability of the CRS Model. Both ^{210}Pb and ^{137}Cs strongly adsorb to clay minerals and organics in the water column and therefore deposition of these isotopes increase with increases in clay and organics content (Robbins and Edgington 1975; Robbins et al. 1979). The presence of sandy substrates, gravel, and woody debris that are commonly encountered in riverine environments therefore effectively reduce the measured radioisotope activity and can lead to an underestimation of the sedimentation rate (i.e., decrease the slope of the logarithmic ^{210}Pb profile). To determine if changes in activity were linked to substrate composition, the grain size information obtained from the ancillary co-located sediment cores was evaluated throughout the depths analyzed for radioisotopes. In addition, the physical characteristics noted in the field sampling boring logs were evaluated to determine if field identified sediment characteristics (e.g., sand lenses, woody debris, etc.) potentially affected the activity profiles.

Radioisotope Evaluation

An evaluation of the radioisotope data for each of the monitoring stations is provided below.

Station RC01

The core log (Attachment A) indicated a 0 to 4 cm sandy silt layer overlaying a fine sandy silt from 4 to 58 cm, a silty sand from 58 to 83 cm, a clayey sandy silt from 83 to 262 cm, and a silty clay from 262 to 275 cm. The surface sediment layer from 0 to 4 cm indicates that a layer of somewhat differing material was recently deposited and, given the stratification below this point, it appears that significant mixing has not recently occurred to depths greater than 4 cm. The variable physical characteristics with depth indicate that that rate of deposition and sediment sources was variable over time at this station which complicates application of the CRS model and interpretation of the ^{210}Pb data.

The ^{7}Be activities are summarized in Table 1 and plotted in Figure 2. The relatively elevated activity in the upper 90 cm of the sediment column indicates recent mixing has occurred in this layer. However, given the half-life of ^{7}Be is 54 days and no major hydrological events have occurred in the last several months, elevated activity to this depth does not likely accurately depict the true mixing layer. Evidence for this inaccuracy is shown through examination of the core log, which shows a distinct sedimentation layer from 0 to 4 cm underlain by three separate strata of depositional materials from the mudline to 83 cm, which were likely deposited over more than several months. It is unclear why ^{7}Be activity would be found in these likely older and deeper stratified layers, but could be due to unknown sampling and analysis artifacts that are difficult to identify.

The ^{137}Cs activities summarized in Table 1 and plotted in Figure 3 are not useable due to the depth of the sediment samples collected relative to the dredging depth attained in 1988. The pit was dredged to a depth of -75 feet NAVD88, approximately 19.1 feet deeper than the identified mudline elevation during coring. Since the core at this station penetrated less than 19.1 feet (i.e., 9 feet) below the mudline, the obtained sediments within the core are known to have deposited since the 1988 dredging event. As discussed above, elevated ^{137}Cs activity primarily occurred in the late 1950s and early 1960s during atmospheric nuclear testing and occurred to a much lesser extent in 1986 during the Chernobyl accident. The ^{137}Cs activities in the core would therefore not be affected by these earlier ^{137}Cs releases and therefore prohibits sediment dating using ^{137}Cs data. It should be noted that ^{137}Cs is found in these cores and the likely source of the isotope is from upstream sediments that were exposed to ^{137}Cs in their prior historical locations. Given the mixing in time and space that occurs with the redistribution and redeposition of these materials, no dates can be feasibly assigned to observed isotope peaks within the core at this station.

The excess ^{210}Pb activities are summarized in Table 2 and plotted in Figure 4. The plot shows that the log excess ^{210}Pb activities are general zero or negative values. This data indicates that there is little to no excess ^{210}Pb activity relative to the supported ^{210}Pb activity in equilibrium with ambient ^{226}Ra already in the sediments. This lack of excess ^{210}Pb activity prohibits dating of the sediments or calculation of the net sedimentation rate using this radioisotope. Review of the core log at this station indicates that although there are strata composed primarily of sand (these layers may effectively reduce the excess ^{210}Pb activity observed), there are several layers of fine-grained materials that would normally be expected to contain excess ^{210}Pb. Consequently, the sediment characteristics by themselves do not explain the lack of excess ^{210}Pb in these cores. The reason for the lack of excess ^{210}Pb is unknown at this time.

Station RC02

The core log (Attachment A) indicated a 0 to 8 cm silty sand layer underlain by a 8 to 36 cm sandy silt, 36 to 49 slightly silty sand, 49 to 293 cm sandy silt, and 293 to 328 cm silty sand. The surface sediment layer from 0 to 8 cm indicates that a layer of somewhat differing material was recently deposited and, given the stratification below this point, it appears that significant mixing has not recently occurred to depths greater than 8 cm. The variable physical characteristics with depth indicate that that rate of deposition and sediment sources was variable over time at this station which complicates application of the CRS model and interpretation of the ^{210}Pb data.

The ^{7}Be activities are summarized in Table 3 and plotted in Figure 5. The relatively elevated activity in the upper 17 cm of the sediment column indicates recent mixing has occurred in this layer. Examination of the core log at this station shows a contiguous surface depositional layer of silty sand from 0 to 8 cm. The material below this depth is very similar to the material noted at station RC01 from 0 to 45 cm. Unlike at station RC01, the ^{7}Be data at this station indicates a relatively similar mixing depth relative to the sediment layering observed in the core log. Thus, the mixed layer appears to be somewhere between 8 and 17 cm.

Consistent with the findings described for station RC-01, the ^{137}Cs activities summarized in Table 3 and plotted in Figure 6 are not useable due to the depth of the sediment samples collected relative to the dredging depth attained in 1986. The pit was dredged to a depth of -75 feet NAVD88, approximately 28.6 feet deeper than the identified mudline elevation during coring. Since the core at this station penetrated less than 28.6 feet (i.e., 9 feet) below the mudline, the obtained sediments within the core are not directly affected by these earlier ^{137}Cs releases and therefore prohibits sediment dating using ^{137}Cs data.

Consistent with the findings described for station RC01, the excess ^{210}Pb activities summarized in Table 4 and plotted in Figure 7 are generally zero or negative values. This data indicates that there is little to no excess ^{210}Pb activity relative to the supported ^{210}Pb activity in equilibrium with ambient ^{226}Ra already in the sediments. This lack of excess ^{210}Pb activity prohibits dating of the sediments or calculation of the net sedimentation rate. Also consistent with the RC01 findings, the core log at this station indicates that, although there are strata composed primarily of sand (these layers may effectively reduce the excess ^{210}Pb activity observed), there are several layers of fine-grained materials that would be normally expected to contain excess ^{210}Pb. As with the station RC01, the reason for the lack of ^{210}Pb activity is unknown.

Station RC483

The core log (Attachment A) indicated 0 to 34 cm of a slightly sandy silt underlain by 34 to 50 cm of a silty sand, 50 to 313 cm of a clayey sandy silt, and 313 to 324 cm of a silty sand. Comparison of the observed physical characteristics at this station relative to stations RC01 and RC02 show that the 0 to 29 cm interval at this station has similar physical characteristics to 0 to 45 cm interval at RC01 and 17 to 40 cm at RC02. In contrast to these stations, station RC483 did not show a shallow surface layer of depositional material.

The identified ^{7}Be data summarized in Table 5 and plotted in Figure 8 indicates no surface mixing layer, as the activity is nearly constant throughout the full core penetration depth. The observed activities at this station are much lower than the observed activities identified at either station RC01 and RC02. This could indicate either relatively recent erosion and/or a lack of any recent substantial deposition in the past few months in this area.

The ^{137}Cs activities are summarized in Table 5 and plotted in Figure 9. Elevated ^{137}Cs activities are present from the mudline to 25 cm. Given this area has been identified as a broad depositional shelf by comparisons of bathymetry over time, the elevated activities in the upper portion of the sediment column are not considered indicative of sediments that were deposited in the early 1960s. It is possible that sediments that were exposed to increased atmospheric fallout during the 1960s have been recently deposited in this area through sediment transport and deposition. Because obvious deeper peaks that could be reasonably expected to be indicative of early 1960s bomb testing do not exist in this core, the data do not allow sediment dating through the use of this isotope.

The excess ^{210}Pb activities are summarized in Table 6 and plotted in Figure 10. The plot shows that the log excess ^{210}Pb activities are generally zero or negative values. This data indicates that there is little to no excess ^{210}Pb activity relative to the supported ^{210}Pb activity in equilibrium with ambient ^{226}Ra already in the sediments. This lack of excess ^{210}Pb activity prohibits dating of the sediments or calculation of the net sedimentation rate using this radioisotope. Review of the core log at this station indicates that although there are strata composed primarily of sand (which may effectively reduce the excess ^{210}Pb activity observed), there are several layers of fine-grained materials that would normally be expected to contain excess ^{210}Pb activities. As with the station RC01 and RC02, the reason for the lack of ^{210}Pb activity is unknown.

Dredge Fill Rate Evaluation

Per a review of the dredging records in the Willamette River, Integral Consultants, Inc., concluded that dredging was conducted at monitoring stations RC01 and RC02 in approximately 1988[1]. Dredging was conducted to a mudline elevation of -75 feet NAVD88 in both of these locations. The mudline at each of these locations was identified to be 19.1 feet and 28.6 feet NAVD88, respectively, during the core collection efforts in 2007. Therefore, the average annual fill rates of the dredge areas over the 19-year fill period is approximately 31 cm/year (i.e., 1 foot/year) and 46 cm/year (i.e., 1.5 feet/year), respectively. Also, the precision bathymetry conducted within the Willamette River in 2004 indicated that the mudline elevations at these stations was -59 feet and -51 feet NAVD88, respectively, leading to an identical 3-year accumulation rate of 1 foot/year and 1.5 feet/year, respectively. This similarity indicates that this fill rate is likely an accurate estimate of long term net sedimentation in these pits for planning purposes. It is important to note that the stratification in these cores would indicate that the actual deposition of sediment in any given year is likely highly variable and may be much higher or much lower (i.e., zero) than this net long-term average. Further, these sedimentation rates cannot be applied to other areas of the site that may appear to be depositional (i.e., quiescent areas) because these pits represent a unique environment of a natural sediment trap in the middle of the river where substantial bed load movement is known to occur.

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Attachment A – Radioisotope Core Logs

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Tables

Table 1
Station RC01 ^{7}Be and ^{137}Cs Data

ID	Section (cm)	Depth (cm)	Depth Variation	^{7}Be Activity	^{7}Be Activity Variation	^{137}Cs Activity	^{137}Cs Activity Variation
LW3-RC01-001	0-2	1	0.5	1.44	0.74	0.1	0.09
LW3-RC01-005	8-10	9	0.5	2.91	0.78	0.32	0.09
LW3-RC01-009	16-18	17	0.5	2.24	1.84	0.23	0.09
LW3-RC01-013	24-26	25	0.5	1.34	1.85	0.41	0.1
LW3-RC01-017	32-34	33	0.5	2.69	1.36	0.34	0.1
LW3-RC01-021	40-42	41	0.5	1.84	-1.22	0.32	0.07
LW3-RC01-025	48-50	49	0.5	-1.58	1.29	0.31	0.11
LW3-RC01-029	56-58	57	0.5	3.06	1.03	0.6	0.12
LW3-RC01-033	64-66	65	0.5	1.51	1.26	0.08	0.1
LW3-RC01-037	72-74	73	0.5	0.5	-1.22	0.1	0.1
LW3-RC01-041	80-82	81	0.5	-1.56	0.88	0.04	0.1
LW3-RC01-045	88-90	89	0.5	1.06	-1.32	0.16	0.07
LW3-RC01-049	96-98	97	0.5	-0.8	-1.19	0.37	0.11
LW3-RC01-053	104-106	105	0.5	-0.57	-0.79	0.17	0.09
LW3-RC01-057	112-114	113	0.5	-0.47	0.93	0.28	0.1
LW3-RC01-061	120-122	121	0.5	0.37	-0.76	0.41	0.1
LW3-RC01-065	128-130	129	0.5	-0.22	-1.19	0.31	0.1
LW3-RC01-069	136-138	137	0.5	-0.24	1.63	0.19	0.07
LW3-RC01-073	144-146	145	0.5	0.35	-1.62	0.36	0.1
LW3-RC01-077	152-154	153	0.5	-0.77	-1.49	0.49	0.1
LW3-RC01-081	160-162	161	0.5	-1.84	-1.3	0.15	0.1
LW3-RC01-085	168-170	169	0.5	-0.23	1.09	0.31	0.1
LW3-RC01-089	176-178	177	0.5	0.35	-0.94	0.17	0.08
LW3-RC01-093	184-186	185	0.5	-0.17	-1.09	0.23	0.09
LW3-RC01-097	192-194	193	0.5	-2.22	1.03	0.36	0.11
LW3-RC01-101	200-202	201	0.5	1.38	-1.21	0.32	0.11
LW3-RC01-105	208-210	209	0.5	-0.81	-1.3	0.17	0.07
LW3-RC01-109	216-218	217	0.5	-0.78	-1.28	0.17	0.08
LW3-RC01-113	224-226	225	0.5	-1.1	-1.07	0.23	0.07
LW3-RC01-117	232-234	233	0.5	-0.43	-0.91	0.35	0.11
LW3-RC01-121	240-242	241	0.5	-0.15	1.19	0.26	0.09
LW3-RC01-125	248-250	249	0.5	0.38	0.83	0.05	0.11
LW3-RC01-129	256-258	257	0.5	0.3	-0.89	0.28	0.09
LW3-RC01-133	264-266	265	0.5	-0.8	0.61	0.26	0.1
LW3-RC01-137	272-274	273	0.5	0.21	0.33	0.35	0.07

Table 2
Station RC01 ^{210}Pb Data

Sample ID	Section (cm)	Depth (cm)	^{226}Ra Activity (Uncorrected)	^{226}Ra Activity Variation (Uncorrected)	^{226}Ra Activity Mean Epoxy Correction	^{226}Ra Activity Variation Epoxy Correction	^{210}Pb Activity (dpm/g)	^{210}Pb Activity Variation (dpm/g)	Background ^{210}Pb Activity (dpm)	Background ^{210}Pb Activity Variation (dpm)	Low Excess ^{210}Pb Activity Variation (dpm)	Mean Excess ^{210}Pb Activity (dpm)	High Excess ^{210}Pb Activity Variation (dpm)	Log Low Excess ^{210}Pb Activity Variation (dpm)	Log Mean Excess ^{210}Pb Activity (dpm)	Log High Excess ^{210}Pb Activity Variation (dpm)
LW3-RC01-001	0-2	1	0.76	0.13	1.321	0.188	0.855	0.066	0.026	0.014	0.063	-0.175	-0.461	-1.199	0.000	0.000
LW3-RC01-005	8-10	9	0.81	0.13	1.321	0.188	1.677	0.163	0.026	0.014	0.732	0.581	0.382	-0.136	-0.236	-0.418
LW3-RC01-009	16-18	17	0.72	1.1	1.321	0.188	1.685	0.17	0.026	0.014	1.934	0.708	-0.930	0.286	-0.150	0.000
LW3-RC01-013	24-26	25	0.89	0.18	1.321	0.188	0.167	0.011	0.026	0.014	-0.660	-1.034	-1.476	0.000	0.000	0.000
LW3-RC01-017	32-34	33	0.68	0.16	1.321	0.188	1.472	0.146	0.026	0.014	0.725	0.548	0.311	-0.140	-0.261	-0.507
LW3-RC01-021	40-42	41	1.05	0.16	1.321	0.188	1.377	0.107	0.026	0.014	0.250	-0.036	-0.381	-0.603	0.000	0.000
LW3-RC01-025	48-50	49	1.24	0.21	1.321	0.188	1.303	0.169	0.026	0.014	-0.045	-0.361	-0.755	0.000	0.000	0.000
LW3-RC01-029	56-58	57	0.93	0.19	1.321	0.188	1.806	0.199	0.026	0.014	0.757	0.552	0.276	-0.121	-0.258	-0.560
LW3-RC01-033	64-66	65	0.92	0.18	1.321	0.188	1.058	0.159	0.026	0.014	0.049	-0.183	-0.482	-1.314	0.000	0.000
LW3-RC01-037	72-74	73	1.15	0.19	1.321	0.188	0.69	0.075	0.026	0.014	-0.485	-0.855	-1.296	0.000	0.000	0.000
LW3-RC01-041	80-82	81	0.97	0.18	1.321	0.188	0.691	0.083	0.026	0.014	-0.299	-0.616	-1.001	0.000	0.000	0.000
LW3-RC01-045	88-90	89	0.91	0.14	1.321	0.188	1.317	0.12	0.026	0.014	0.313	0.089	-0.187	-0.505	-1.050	0.000
LW3-RC01-049	96-98	97	1	0.19	1.321	0.188	1.817	0.169	0.026	0.014	0.718	0.470	0.151	-0.144	-0.328	-0.821
LW3-RC01-053	104-106	105	0.8	0.16	1.321	0.188	2.397	0.262	0.026	0.014	1.398	1.314	1.171	0.145	0.119	0.069
LW3-RC01-057	112-114	113	0.87	0.14	1.321	0.188	2.213	0.191	0.026	0.014	1.183	1.038	0.841	0.073	0.016	-0.075
LW3-RC01-061	120-122	121	0.78	0.14	1.321	0.188	1.981	0.159	0.026	0.014	1.085	0.925	0.712	0.035	-0.034	-0.147
LW3-RC01-065	128-130	129	0.76	0.13	1.321	0.188	2.196	0.209	0.026	0.014	1.261	1.166	1.023	0.101	0.067	0.010
LW3-RC01-069	136-138	137	0.87	0.14	1.321	0.188	1.195	0.098	0.026	0.014	0.258	0.020	-0.270	-0.589	-1.699	0.000
LW3-RC01-073	144-146	145	0.92	0.18	1.321	0.188	1.598	0.14	0.026	0.014	0.608	0.357	0.039	-0.216	-0.447	-1.411
LW3-RC01-077	152-154	153	0.68	0.16	1.321	0.188	2.121	0.154	0.026	0.014	1.366	1.197	0.968	0.135	0.078	-0.014
LW3-RC01-081	160-162	161	0.94	0.18	1.321	0.188	1.456	0.135	0.026	0.014	0.448	0.189	-0.138	-0.349	-0.725	0.000
LW3-RC01-085	168-170	169	0.96	0.17	1.321	0.188	0.966	0.096	0.026	0.014	-0.037	-0.328	-0.682	0.000	0.000	0.000
LW3-RC01-089	176-178	177	1.01	0.16	1.321	0.188	0.962	0.115	0.026	0.014	-0.128	-0.398	-0.728	0.000	0.000	0.000
LW3-RC01-093	184-186	185	0.83	0.16	1.321	0.188	1.358	0.158	0.026	0.014	0.429	0.236	-0.017	-0.368	-0.627	0.000
LW3-RC01-097	192-194	193	0.7	0.17	1.321	0.188	1.763	0.2	0.026	0.014	0.951	0.813	0.611	-0.022	-0.090	-0.214
LW3-RC01-101	200-202	201	0.73	0.17	1.321	0.188	1.949	0.184	0.026	0.014	1.119	0.959	0.736	0.049	-0.018	-0.133
LW3-RC01-105	208-210	209	0.99	0.15	1.321	0.188	0.952	0.087	0.026	0.014	-0.099	-0.381	-0.721	0.000	0.000	0.000
LW3-RC01-109	216-218	217	0.93	0.12	1.321	0.188	1.097	0.118	0.026	0.014	0.049	-0.157	-0.409	-1.307	0.000	0.000
LW3-RC01-113	224-226	225	1.14	0.17	1.321	0.188	1.114	0.112	0.026	0.014	-0.109	-0.418	-0.790	0.000	0.000	0.000
LW3-RC01-117	232-234	233	1.07	0.19	1.321	0.188	1.766	0.178	0.026	0.014	0.579	0.327	0.003	-0.237	-0.486	-2.456
LW3-RC01-121	240-242	241	1.24	0.19	1.321	0.188	1.545	0.134	0.026	0.014	0.209	-0.119	-0.518	-0.679	0.000	0.000
LW3-RC01-125	248-250	249	1.05	0.2	1.321	0.188	0.952	0.088	0.026	0.014	-0.111	-0.461	-0.885	0.000	0.000	0.000
LW3-RC01-129	256-258	257	0.76	0.12	1.321	0.188	1.192	0.136	0.026	0.014	0.319	0.162	-0.039	-0.496	-0.790	0.000
LW3-RC01-133	264-266	265	0.85	0.14	1.321	0.188	1.806	0.132	0.026	0.014	0.858	0.657	0.405	-0.067	-0.182	-0.393
LW3-RC01-137	272-274	273	0.73	0.1	1.321	0.188	2.73	0.207	0.026	0.014	1.797	1.740	1.645	0.255	0.241	0.216

Table 3
Station RC02 ^{7}Be and ^{137}Cs Data

ID	Section (cm)	Depth (cm)	Depth Variation	^{7}Be Activity	^{7}Be Activity Variation	^{137}Cs Activity	^{137}Cs Activity Variation
LW3-RC02-001	0-2	1	0.5	2.26	0.64	0.21	0.1
LW3-RC02-005	8-10	9	0.5	2.63	0.74	0.41	0.06
LW3-RC02-009	16-18	17	0.5	3.05	0.77	0.38	0.06
LW3-RC02-013	24-26	25	0.5	0.93	1.96	0.25	0.09
LW3-RC02-017	32-34	33	0.5	0.34	2.09	0.22	0.12
LW3-RC02-021	40-42	41	0.5	0.98	1.7	0.06	0.22
LW3-RC02-025	48-50	49	0.5	-0.99	-1.55	0.13	0.1
LW3-RC02-029	56-58	57	0.5	1	2.41	0.42	0.05
LW3-RC02-033	64-66	65	0.5	1.87	1.86	0.52	0.04
LW3-RC02-037	72-74	73	0.5	0.53	2.19	0.53	0.05
LW3-RC02-041	80-82	81	0.5	1.3	1.34	0.42	0.05
LW3-RC02-045	88-90	89	0.5	-0.6	-1.27	0.18	0.11
LW3-RC02-049	96-98	97	0.5	0.25	1.01	0.2	0.08
LW3-RC02-053	104-106	105	0.5	-0.41	-1.06	0.28	0.06
LW3-RC02-057	112-114	113	0.5	-0.65	-0.8	0.4	0.06
LW3-RC02-061	120-122	121	0.5	0.44	0.8	0.27	0.08
LW3-RC02-065	128-130	129	0.5	-1.08	-0.84	0.35	0.07
LW3-RC02-069	136-138	137	0.5	-3.82	-2.49	0.28	0.09
LW3-RC02-073	144-146	145	0.5	-2.29	-2.21	0.34	0.08
LW3-RC02-077	152-154	153	0.5	-1.28	-2.27	0.33	0.08
LW3-RC02-081	160-162	161	0.5	-0.57	-1.58	0.39	0.06
LW3-RC02-085	168-170	169	0.5	0.21	1.08	0.16	0.1
LW3-RC02-089	176-178	177	0.5	-0.34	-1.19	0.28	0.06
LW3-RC02-093	184-186	185	0.5	1.38	0.95	0.46	0.05
LW3-RC02-097	192-194	193	0.5	-0.8	-1.62	0.26	0.09
LW3-RC02-101	200-202	201	0.5	-2.69	-1.95	0.47	0.06
LW3-RC02-105	208-210	209	0.5	0.05	1.57	0.14	0.12
LW3-RC02-109	216-218	217	0.5	0.18	2.45	0.36	0.08
LW3-RC02-113	224-226	225	0.5	-3.17	-2.02	0.25	0.09
LW3-RC02-117	232-234	233	0.5	-1.22	-1.09	0.09	0.11
LW3-RC02-121	240-242	241	0.5	0.33	1.7	0.29	0.08
LW3-RC02-125	248-250	249	0.5	0.46	1.27	0.1	0.17
LW3-RC02-129	256-258	257	0.5	0.03	1.68	0.37	0.05
LW3-RC02-133	264-266	265	0.5	-1.86	-2.41	0.35	0.07
LW3-RC02-137	272-274	273	0.5	0.1	1.76	0.15	0.12
LW3-RC02-141	280-282	281	0.5	-1.9	-1.03	0.18	0.14
LW3-RC02-145	288-290	289	0.5	-1.6	-1.1	0.03	0.97
LW3-RC02-149	296-298	297	0.5	1.85	0.96	0.12	0.07

Table 4
Station RC02 ^{210}Pb Data

ID	Section (cm)	Depth (cm)	Mean ^{226}Ra Activity (Uncorrected)	^{226}Ra Activity Variation (Uncorrected)	^{226}Ra Activity Mean Epoxy Correction	^{226}Ra Activity Variation Epoxy Correction	^{210}Pb Activity (dpm/g)	^{210}Pb Activity Variation (dpm/g)	Background ^{210}Pb Activity (dpm)	Background ^{210}Pb Activity Variation (dpm)	Low Excess ^{210}Pb Activity Variation (dpm)	Mean Excess ^{210}Pb Activity (dpm)	High Excess ^{210}Pb Activity Variation (dpm)	Log Low Excess ^{210}Pb Activity Variation (dpm)	Log Mean Excess ^{210}Pb Activity (dpm)	Log High Excess ^{210}Pb Activity Variation (dpm)
LW3-RC02-001	0-2	1	0.76	0.13	1.304	0.194	0.69	0.07	0.026	0.014	-0.091	-0.327	-0.613	0.000	0.000	0.000
LW3-RC02-005	8-10	9	0.87	0.14	1.304	0.194	1.05	0.08	0.026	0.014	0.148	-0.110	-0.423	-0.831	0.000	0.000
LW3-RC02-009	16-18	17	1.18	0.15	1.304	0.194	1.26	0.15	0.026	0.014	-0.045	-0.305	-0.622	0.000	0.000	0.000
LW3-RC02-013	24-26	25	1.18	0.19	1.304	0.194	1.28	0.09	0.026	0.014	0.079	-0.285	-0.722	-1.102	0.000	0.000
LW3-RC02-017	32-34	33	1.29	0.21	1.304	0.194	1.36	0.1	0.026	0.014	0.049	-0.348	-0.827	-1.308	0.000	0.000
LW3-RC02-021	40-42	41	0.93	0.15	1.304	0.194	0.52	0.05	0.026	0.014	-0.408	-0.719	-1.088	0.000	0.000	0.000
LW3-RC02-025	48-50	49	0.93	0.15	1.304	0.194	0.52	0.08	0.026	0.014	-0.438	-0.719	-1.058	0.000	0.000	0.000
LW3-RC02-029	56-58	57	0.64	0.12	1.304	0.194	1.94	0.2	0.026	0.014	1.151	1.079	0.962	0.061	0.033	-0.017
LW3-RC02-033	64-66	65	0.83	0.14	1.304	0.194	1.75	0.23	0.026	0.014	0.742	0.642	0.487	-0.130	-0.193	-0.313
LW3-RC02-037	72-74	73	1.14	0.2	1.304	0.194	1.5	0.13	0.026	0.014	0.315	-0.013	-0.417	-0.502	0.000	0.000
LW3-RC02-041	80-82	81	0.76	0.13	1.304	0.194	1.79	0.13	0.026	0.014	0.949	0.773	0.547	-0.023	-0.112	-0.262
LW3-RC02-045	88-90	89	0.84	0.13	1.304	0.194	1.14	0.14	0.026	0.014	0.200	0.019	-0.213	-0.699	-1.730	0.000
LW3-RC02-049	96-98	97	0.92	0.12	1.304	0.194	0.95	0.1	0.026	0.014	-0.050	-0.276	-0.548	0.000	0.000	0.000
LW3-RC02-053	104-106	105	0.74	0.11	1.304	0.194	0.9	0.09	0.026	0.014	0.099	-0.091	-0.323	-1.006	0.000	0.000
LW3-RC02-057	112-114	113	1.24	0.16	1.304	0.194	1.57	0.14	0.026	0.014	0.219	-0.073	-0.427	-0.659	0.000	0.000
LW3-RC02-061	120-122	121	1.12	0.15	1.304	0.194	1.42	0.11	0.026	0.014	0.221	-0.066	-0.412	-0.655	0.000	0.000
LW3-RC02-065	128-130	129	1.06	0.16	1.304	0.194	1.35	0.15	0.026	0.014	0.189	-0.058	-0.368	-0.724	0.000	0.000
LW3-RC02-069	136-138	137	1.2	0.2	1.304	0.194	1.14	0.09	0.026	0.014	-0.072	-0.451	-0.907	0.000	0.000	0.000
LW3-RC02-073	144-146	145	1.13	0.2	1.304	0.194	1.17	0.11	0.026	0.014	0.016	-0.330	-0.752	-1.804	0.000	0.000
LW3-RC02-077	152-154	153	1.18	0.2	1.304	0.194	1.23	0.11	0.026	0.014	0.020	-0.335	-0.767	-1.695	0.000	0.000
LW3-RC02-081	160-162	161	0.99	0.15	1.304	0.194	1.64	0.13	0.026	0.014	0.566	0.323	0.022	-0.247	-0.491	-1.652
LW3-RC02-085	168-170	169	1.01	0.12	1.304	0.194	1.23	0.12	0.026	0.014	0.110	-0.113	-0.383	-0.958	0.000	0.000
LW3-RC02-089	176-178	177	0.81	0.11	1.304	0.194	1.07	0.11	0.026	0.014	0.171	-0.012	-0.238	-0.767	0.000	0.000
LW3-RC02-093	184-186	185	0.89	0.14	1.304	0.194	1.56	0.13	0.026	0.014	0.586	0.373	0.107	-0.232	-0.428	-0.970
LW3-RC02-097	192-194	193	1.03	0.14	1.304	0.194	1.57	0.14	0.026	0.014	0.430	0.201	-0.083	-0.366	-0.697	0.000
LW3-RC02-101	200-202	201	1	0.16	1.304	0.194	1.22	0.1	0.026	0.014	0.176	-0.110	-0.458	-0.755	0.000	0.000
LW3-RC02-105	208-210	209	0.92	0.14	1.304	0.194	0.7	0.06	0.026	0.014	-0.238	-0.526	-0.868	0.000	0.000	0.000
LW3-RC02-109	216-218	217	1.21	0.2	1.304	0.194	1.01	0.1	0.026	0.014	-0.223	-0.594	-1.042	0.000	0.000	0.000
LW3-RC02-113	224-226	225	1.06	0.15	1.304	0.194	1.22	0.14	0.026	0.014	0.058	-0.188	-0.493	-1.237	0.000	0.000
LW3-RC02-117	232-234	233	0.85	0.1	1.304	0.194	0.74	0.1	0.026	0.014	-0.205	-0.394	-0.623	0.000	0.000	0.000
LW3-RC02-121	240-242	241	0.71	0.13	1.304	0.194	0.65	0.08	0.026	0.014	-0.086	-0.302	-0.568	0.000	0.000	0.000
LW3-RC02-125	248-250	249	0.73	0.1	1.304	0.194	0.79	0.1	0.026	0.014	-0.021	-0.188	-0.393	0.000	0.000	0.000
LW3-RC02-129	256-258	257	1.06	0.16	1.304	0.194	0.59	0.07	0.026	0.014	-0.491	-0.818	-1.208	0.000	0.000	0.000
LW3-RC02-133	264-266	265	1.33	0.21	1.304	0.194	1.31	0.14	0.026	0.014	-0.085	-0.450	-0.897	0.000	0.000	0.000
LW3-RC02-137	272-274	273	1.18	0.17	1.304	0.194	0.6	0.09	0.026	0.014	-0.623	-0.965	-1.372	0.000	0.000	0.000
LW3-RC02-141	280-282	281	1.09	0.16	1.304	0.194	1.47	0.17	0.026	0.014	0.256	0.023	-0.273	-0.592	-1.645	0.000
LW3-RC02-145	288-290	289	0.85	0.15	1.304	0.194	1.16	0.09	0.026	0.014	0.281	0.026	-0.288	-0.551	-1.592	0.000
LW3-RC02-149	296-298	297	0.91	0.1	1.304	0.194	0.73	0.06	0.026	0.014	-0.241	-0.483	-0.763	0.000	0.000	0.000

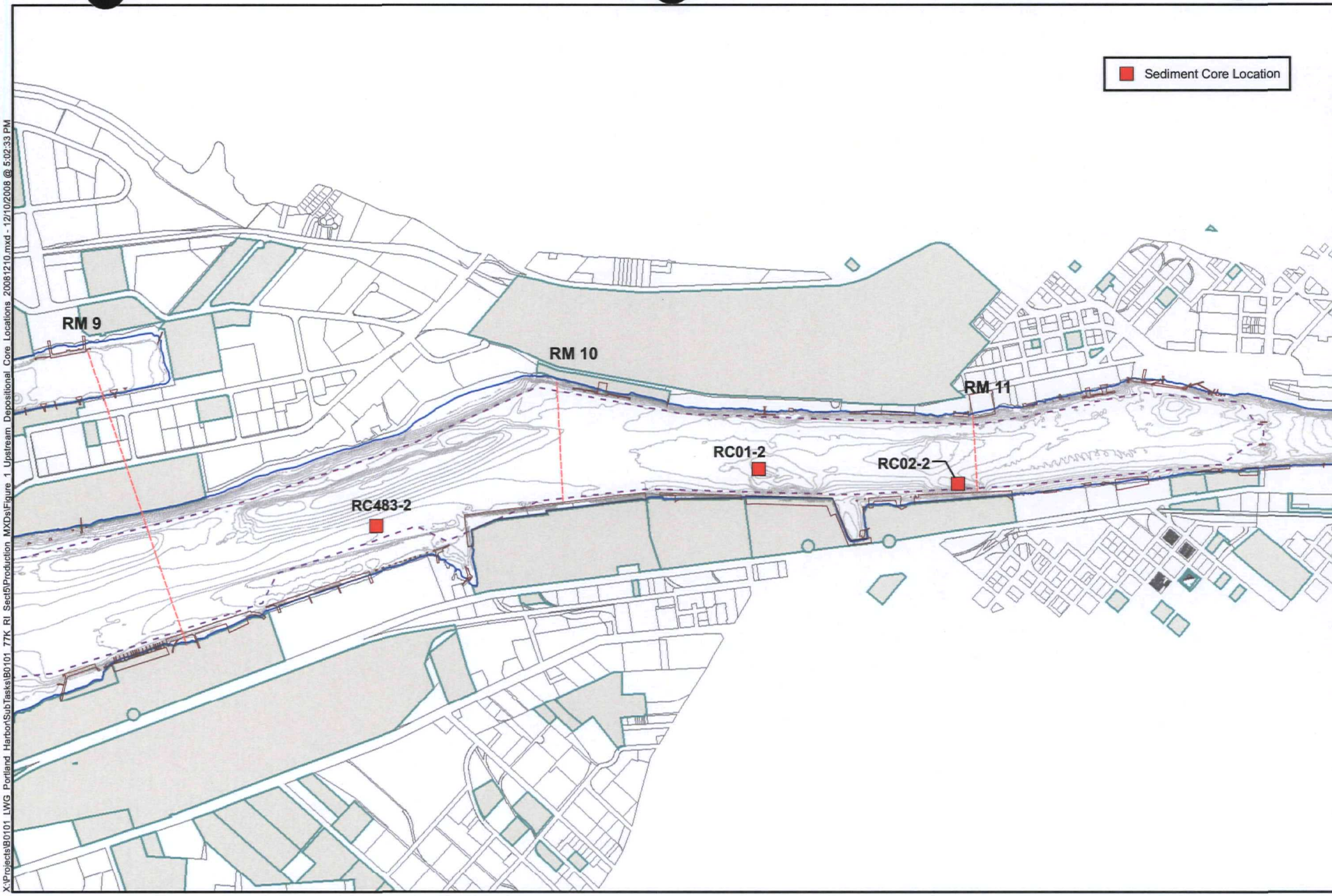
Table 5
Station RC483 7Be and 137Cs Data

ID	Section (cm)	Depth (cm)	Depth Variation	^{7}Be Activity	^{7}Be Activity Variation	^{137}Cs Activity	^{137}Cs Activity Variation
LW3-RC483-001	0-2	1	0.5	0.87	0.57	2.87	0.43
LW3-RC483-005	10-Aug	9	0.5	0.63	0.58	3.75	0.58
LW3-RC483-009	16-18	17	0.5	0.83	0.54	2.99	0.54
LW3-RC483-013	24-26	25	0.5	0.82	0.49	3.62	0.49
LW3-RC483-017	32-34	33	0.5	1	0.51	0.33	0.51
LW3-RC483-021	40-42	41	0.5	0.78	0.32	0.64	0.32
LW3-RC483-025	48-50	49	0.5	0.9	-0.48	-0.92	-0.48
LW3-RC483-029	56-58	57	0.5	0.76	0.47	1.2	0.47
LW3-RC483-033	64-66	65	0.5	0.96	-0.47	-0.39	-0.47
LW3-RC483-037	72-74	73	0.5	1	0	-0.57	0
LW3-RC483-041	80-82	81	0.5	0.82	-0.53	-2.99	-0.53
LW3-RC483-045	88-90	89	0.5	0.97	-0.36	-0.82	-0.36
LW3-RC483-049	96-98	97	0.5	0.88	-0.46	-0.15	-0.46
LW3-RC483-053	104-106	105	0.5	0.92	0.34	0.51	0.34
LW3-RC483-057	112-114	113	0.5	0.91	-0.49	-0.56	-0.49
LW3-RC483-061	120-122	121	0.5	0.85	-0.49	-1.59	-0.49
LW3-RC483-065	128-130	129	0.5	1.02	-0.49	-0.03	-0.49
LW3-RC483-069	136-138	137	0.5	0.98	0.61	0.15	0.61
LW3-RC483-073	144-146	145	0.5	0.86	0.49	1.34	0.49
LW3-RC483-077	152-154	153	0.5	0.88	-0.36	-1.81	-0.36
LW3-RC483-081	160-162	161	0.5	0.87	-0.5	-2.45	-0.5
LW3-RC483-085	168-170	169	0.5	0.91	-0.58	-2.92	-0.58
LW3-RC483-089	176-178	177	0.5	0.89	-0.35	-1.51	-0.35
LW3-RC483-093	184-186	185	0.5	0.63	0.44	0.33	0.44
LW3-RC483-097	192-194	193	0.5	1.07	-0.4	-0.58	-0.4
LW3-RC483-101	200-202	201	0.5	0.92	-0.47	-1.5	-0.47
LW3-RC483-105	208-210	209	0.5	0.78	0.5	1.57	0.5
LW3-RC483-109	216-218	217	0.5	0.78	-0.51	-23.1	-0.51
LW3-RC483-113	224-226	225	0.5	0.79	0.48	0.02	0.48
LW3-RC483-117	232-234	233	0.5	1	0.43	0.85	0.43
LW3-RC483-121	240-242	241	0.5	1.01	-0.52	-0.47	-0.52
LW3-RC483-125	248-250	249	0.5	1.02	0.58	0.45	0.58
LW3-RC483-129	256-258	257	0.5	0.81	-0.44	-1.1	-0.44
LW3-RC483-133	264-266	265	0.5	1.07	0.48	0.89	0.48
LW3-RC483-137	272-274	273	0.5	0.97	0.36	1.33	0.36
LW3-RC483-141	280-282	281	0.5	0.95	-0.46	-0.16	-0.46
LW3-RC483-145	288-290	289	0.5	1.02	-0.57	-0.83	-0.57
LW3-RC483-149	296-298	297	0.5	1.03	0.53	0.26	0.53

Table 6
Station RC483 ^{210}Pb Data

ID	Section (cm)	Depth (cm)	^{226}Ra Activity (Not-Corrected)	^{226}Ra Activity Variation (Not-Corrected)	Mean Epoxy Correction	Epoxy Variation Correction	Low ^{226}Ra Activity Variation (Epoxy Corrected)	Mean ^{226}Ra Activity (Epoxy Corrected)	High ^{226}Ra Activity Variation (Epoxy Corrected)	^{210}Pb Activity (dpm/g)	^{210}Pb Activity Variation (dpm/g)	Background ^{210}Pb Activity (dpm)	Background ^{210}Pb Activity Variation (dpm)	Low Excess ^{210}Pb Activity Variation (dpm)	Mean Excess ^{210}Pb Activity (dpm)	High Excess ^{210}Pb Activity Variation (dpm)	Log Low Excess ^{210}Pb Activity Variation (dpm)	Log Mean Excess ^{210}Pb Activity (dpm)	Log High Excess ^{210}Pb Activity Variation (dpm)
LW3-RC483-001	0-2	1	1.85	0.05	1.294	0.171	2.023	2.395	2.784	0.69	0.07	0.026	0.014	-1.415	-1.731	-2.064	0.000	0.000	0.000
LW3-RC483-005	8-10	9	1.82	0.07	1.294	0.171	1.966	2.356	1.18	0.09	0.07	0.026	0.014	-1.958	-2.292	-1.060	0.000	0.000	0.000
LW3-RC483-009	16-18	17	2.68	0.04	1.294	0.171	2.966	3.469	1.24	0.1	0.07	0.026	0.014	-2.948	-3.395	-1.110	0.000	0.000	0.000
LW3-RC483-013	24-26	25	1.3	0.08	1.294	0.171	1.371	1.683	6.99	1.08	0.07	0.026	0.014	-0.373	-0.629	-5.880	0.000	0.000	0.000
LW3-RC483-017	32-34	33	1.85	0.06	1.294	0.171	2.011	2.395	1.14	0.14	0.07	0.026	0.014	-1.953	-2.281	-0.970	0.000	0.000	0.000
LW3-RC483-021	40-42	41	0.67	0.11	1.294	0.171	0.629	0.867	0.55	0.07	0.07	0.026	0.014	-0.641	-0.823	-0.450	0.000	0.000	0.000
LW3-RC483-025	48-50	49	1.69	0.06	1.294	0.171	1.832	2.187	1.24	0.13	0.07	0.026	0.014	-1.784	-2.083	-1.080	0.000	0.000	0.000
LW3-RC483-029	56-58	57	1.4	0.08	1.294	0.171	1.483	1.812	1.41	0.23	0.07	0.026	0.014	-1.335	-1.608	-1.150	0.000	0.000	0.000
LW3-RC483-033	64-66	65	3.64	0.03	1.294	0.171	4.056	4.711	2.35	0.32	0.07	0.026	0.014	-3.818	-4.417	-2.000	0.000	0.000	0.000
LW3-RC483-037	72-74	73	3.15	0.04	1.294	0.171	3.495	4.077	2.57	0.29	0.07	0.026	0.014	-3.287	-3.813	-2.250	0.000	0.000	0.000
LW3-RC483-041	80-82	81	1.46	0.08	1.294	0.171	1.551	1.890	1.84	0.19	0.07	0.026	0.014	-1.443	-1.726	-1.620	0.000	0.000	0.000
LW3-RC483-045	88-90	89	2.59	0.03	1.294	0.171	2.877	3.352	0.97	0.09	0.07	0.026	0.014	-2.869	-3.288	-0.850	0.000	0.000	0.000
LW3-RC483-049	96-98	97	1.09	0.1	1.294	0.171	1.112	1.411	1.71	0.17	0.07	0.026	0.014	-1.024	-1.267	-1.510	0.000	0.000	0.000
LW3-RC483-053	104-106	105	2.14	0.04	1.294	0.171	2.360	2.770	1.06	0.16	0.07	0.026	0.014	-2.282	-2.636	-0.870	0.000	0.000	0.000
LW3-RC483-057	112-114	113	3.1	0.04	1.294	0.171	3.438	4.012	1.98	0.19	0.07	0.026	0.014	-3.330	-3.848	-1.760	0.000	0.000	0.000
LW3-RC483-061	120-122	121	1.9	0.06	1.294	0.171	2.068	2.459	1.37	0.12	0.07	0.026	0.014	-2.030	-2.365	-1.220	0.000	0.000	0.000
LW3-RC483-065	128-130	129	1.87	0.06	1.294	0.171	2.034	2.420	1.49	0.13	0.07	0.026	0.014	-1.986	-2.316	-1.330	0.000	0.000	0.000
LW3-RC483-069	136-138	137	2.33	0.06	1.294	0.171	2.551	3.016	1.27	0.1	0.07	0.026	0.014	-2.533	-2.942	-1.140	0.000	0.000	0.000
LW3-RC483-073	144-146	145	2.74	0.04	1.294	0.171	3.034	3.546	1.59	0.18	0.07	0.026	0.014	-2.936	-3.392	-1.380	0.000	0.000	0.000
LW3-RC483-077	152-154	153	1.93	0.05	1.294	0.171	2.112	2.498	1.22	0.13	0.07	0.026	0.014	-2.064	-2.394	-1.060	0.000	0.000	0.000
LW3-RC483-081	160-162	161	2.86	0.04	1.294	0.171	3.169	3.702	1.99	0.19	0.07	0.026	0.014	-3.061	-3.538	-1.770	0.000	0.000	0.000
LW3-RC483-085	168-170	169	2.49	0.05	1.294	0.171	2.742	3.223	0.01	0.08	0.07	0.026	0.014	-2.744	-3.169	0.100	0.000	0.000	-1.000
LW3-RC483-089	176-178	177	2.04	0.04	1.294	0.171	2.247	2.640	0.83	0.09	0.07	0.026	0.014	-2.239	-2.576	-0.710	0.000	0.000	0.000
LW3-RC483-093	184-186	185	1.23	0.08	1.294	0.171	1.292	1.592	1.1	0.11	0.07	0.026	0.014	-1.264	-1.508	-0.960	0.000	0.000	0.000
LW3-RC483-097	192-194	193	2.16	0.05	1.294	0.171	2.371	2.796	1.43	0.16	0.07	0.026	0.014	-2.293	-2.662	-1.240	0.000	0.000	0.000
LW3-RC483-101	200-202	201	2.21	0.05	1.294	0.171	2.427	2.860	1.52	0.14	0.07	0.026	0.014	-2.369	-2.746	-1.350	0.000	0.000	0.000
LW3-RC483-105	208-210	209	1.05	0.13	1.294	0.171	1.034	1.359	1.48	0.13	0.07	0.026	0.014	-0.986	-1.255	-1.320	0.000	0.000	0.000
LW3-RC483-109	216-218	217	1.88	0.08	1.294	0.171	2.023	2.433	2.3	0.24	0.07	0.026	0.014	-1.865	-2.219	-2.030	0.000	0.000	0.000
LW3-RC483-113	224-226	225	1.69	0.07	1.294	0.171	1.820	2.187	1.82	0.21	0.07	0.026	0.014	-1.692	-2.003	-1.580	0.000	0.000	0.000
LW3-RC483-117	232-234	233	1.86	0.05	1.294	0.171	2.034	2.407	1.08	0.13	0.07	0.026	0.014	-1.986	-2.303	-0.920	0.000	0.000	0.000
LW3-RC483-121	240-242	241	1.05	0.11	1.294	0.171	1.056	1.359	1.19	0.13	0.07	0.026	0.014	-1.008	-1.255	-1.030	0.000	0.000	0.000
LW3-RC483-125	248-250	249	1	0.13	1.294	0.171	0.978	1.294	1	0.14	0.07	0.026	0.014	-0.920	-1.180	-0.830	0.000	0.000	0.000
LW3-RC483-129	256-258	257	1.1	0.09	1.294	0.171	1.135	1.424	1.35	0.1	0.07	0.026	0.014	-1.117	-1.350	-1.220	0.000	0.000	0.000
LW3-RC483-133	264-266	265	1.6	0.07	1.294	0.171	1.719	2.071	1.74	0.48	0.07	0.026	0.014	-1.321	-1.617	-1.230	0.000	0.000	0.000
LW3-RC483-137	272-274	273	1.46	0.06	1.294	0.171	1.573	1.890	0.83	0.08	0.07	0.026	0.014	-1.575	-1.836	-0.720	0.000	0.000	0.000
LW3-RC483-141	280-282	281	1.08	0.1	1.294	0.171	1.101	1.398	1.38	0.13	0.07	0.026	0.014	-1.053	-1.294	-1.220	0.000	0.000	0.000
LW3-RC483-145	288-290	289	2.28	0.06	1.294	0.171	2.495	2.951	2.03	0.18	0.07	0.026	0.014	-2.397	-2.797	-1.820	0.000	0.000	0.000
LW3-RC483-149	296-298	297	1.14	0.11	1.294	0.171	1.157	1.476	1.43	0.13	0.07	0.026	0.014	-1.109	-1.372	-1.270	0.000	0.000	0.000

Figures



integral consulting inc.

LWG Lower Willamette Group

0 0.25 0.5 Miles

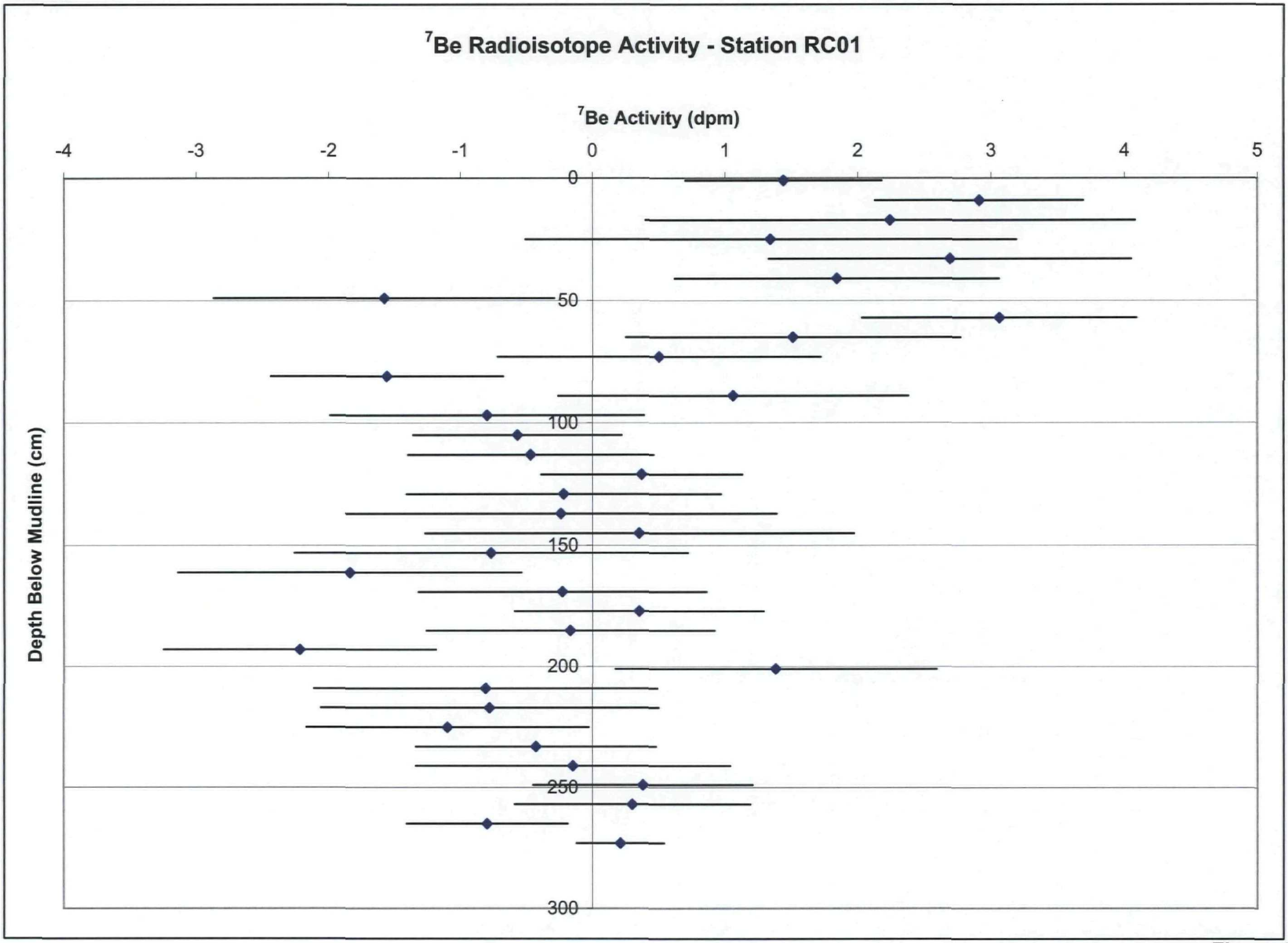
FEATURE SOURCES:
Transportation, Property, or Boundaries: Metro RLIS.
Channel & River Miles: US Army Corps of Engineers.
Bathymetric Information: David Evans and Associates, Inc.

N

Map Features

- River Miles
- Docks and Structures
- Navigation Channel
- Bathymetry (5 ft interval)
- Upland Sites (2008)
- Waterfront Taxlots

Figure 1
Portland Harbor RI/FS
Draft Remedial Investigation Report
LWG Round 3A Radioisotope Monitoring Stations



ANCHOR ENVIRONMENTAL, L.L.C.

Figure 2
Beryllium-7 Radioisotope Activity - Station RC01
Willamette River

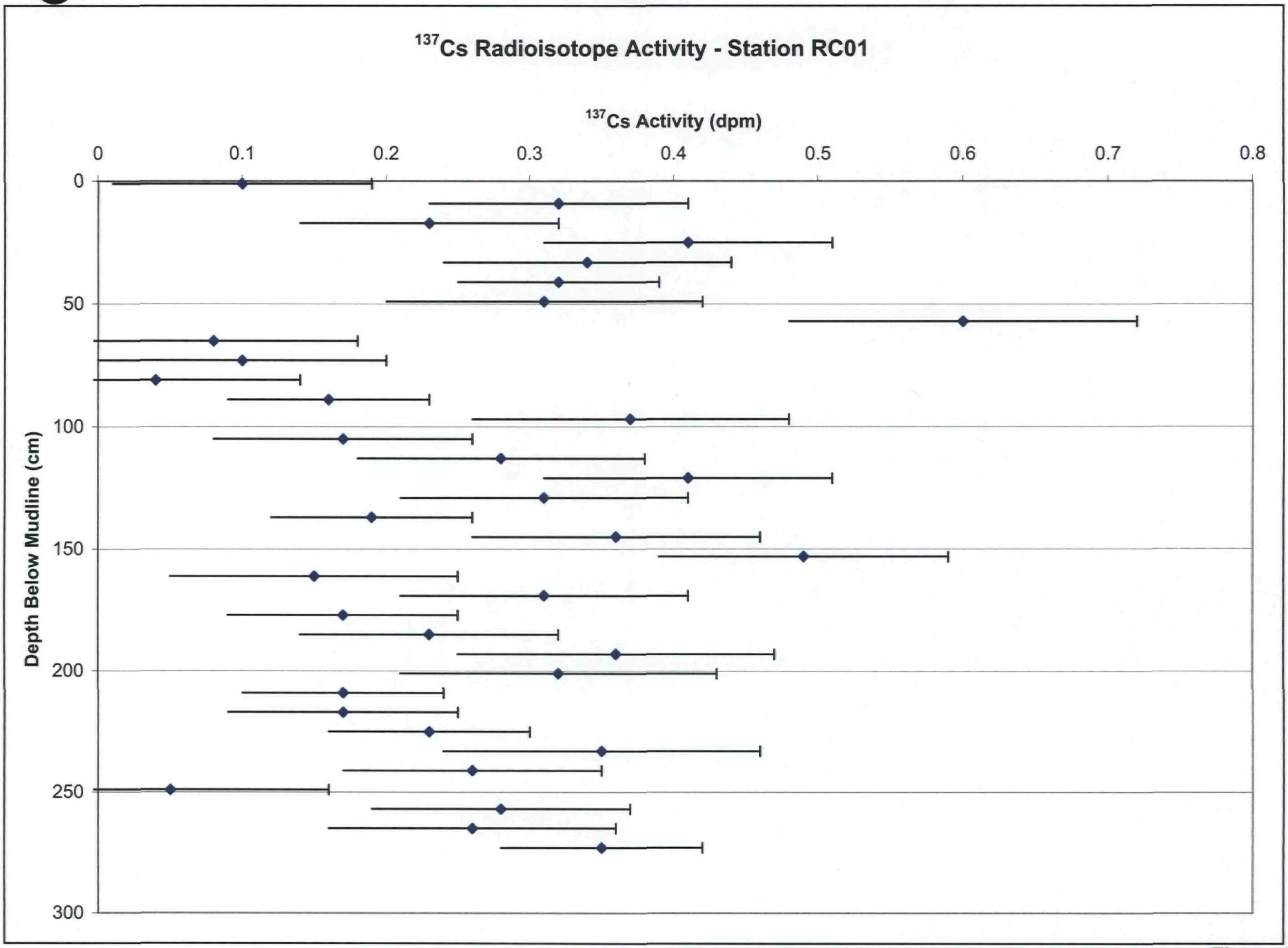


Figure 3
Cesium-137 Radioisotope Activity - Station RC01
Willamette River

ANCHOR ENVIRONMENTAL, L.L.C.

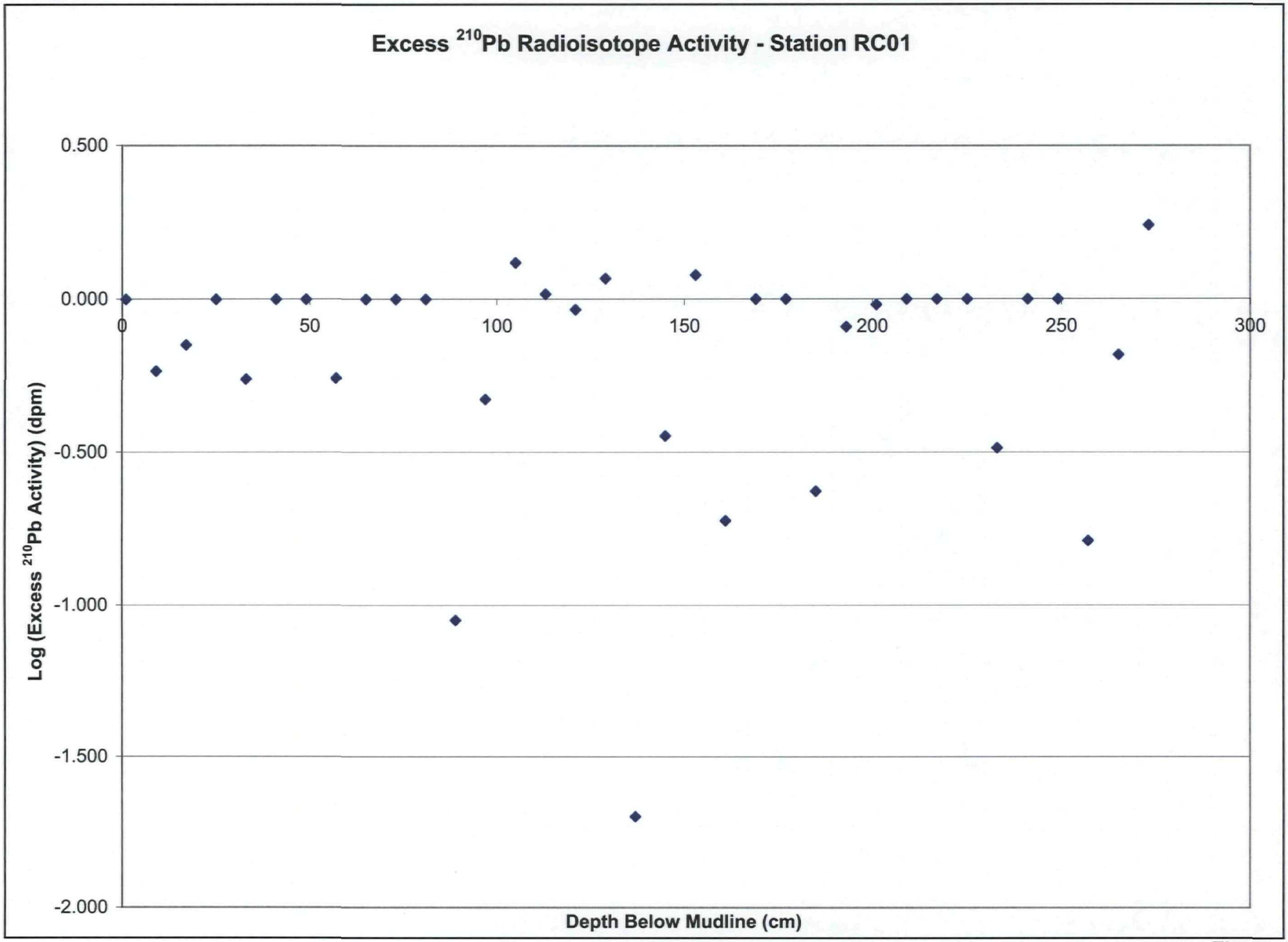


Figure 4
Excess Lead-210 Radioisotope Activity - Station RC01
Willamette River

ANCHOR ENVIRONMENTAL, L.L.C.

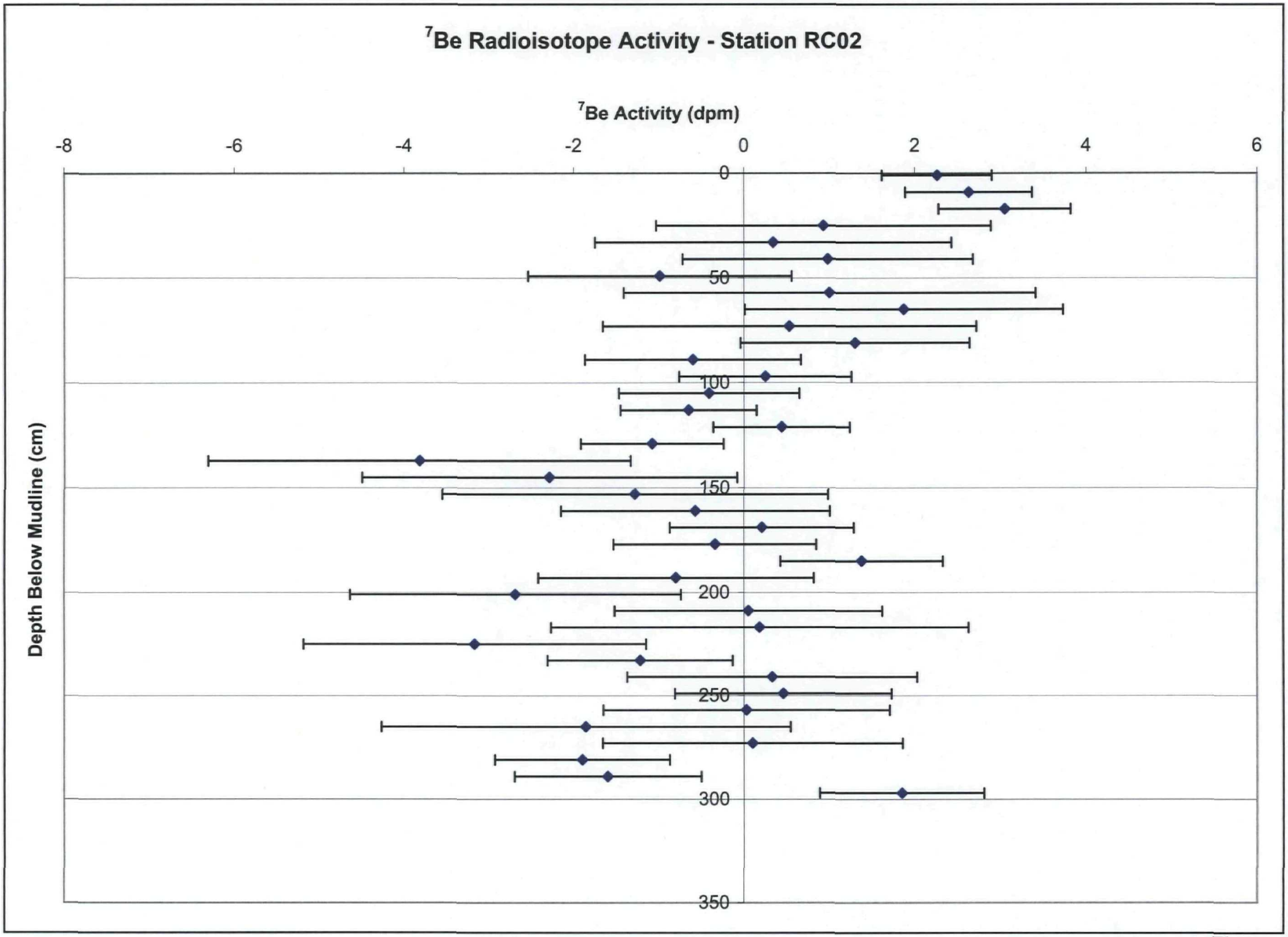


Figure 5
Beryllium-7 Radioisotope Activity - Station RC02
Willamette River

ANCHOR ENVIRONMENTAL, L.L.C.

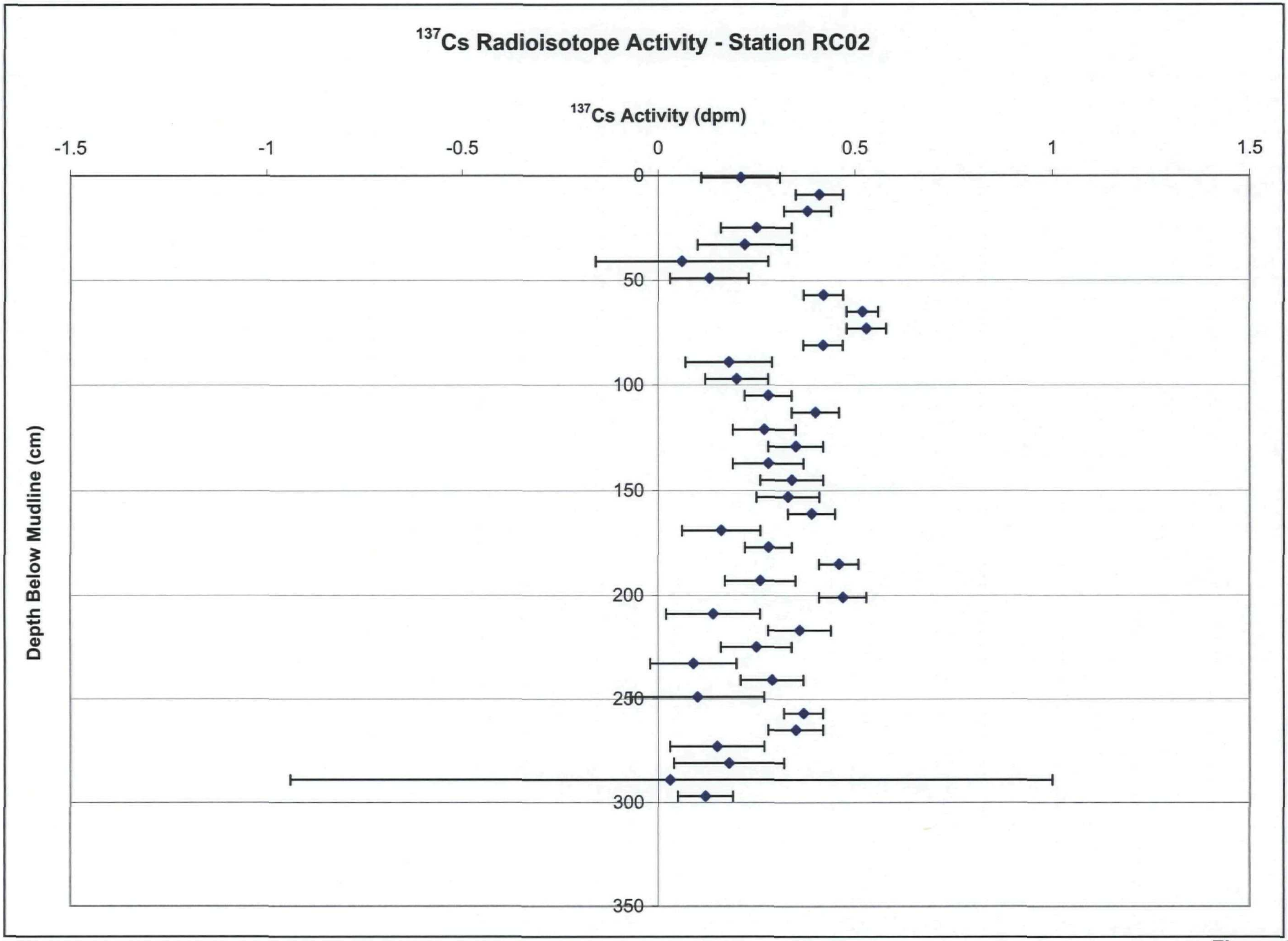


Figure 6
Cesium-137 Radioisotope Activity - Station RC02
Willamette River

ANCHOR ENVIRONMENTAL, L.L.C.

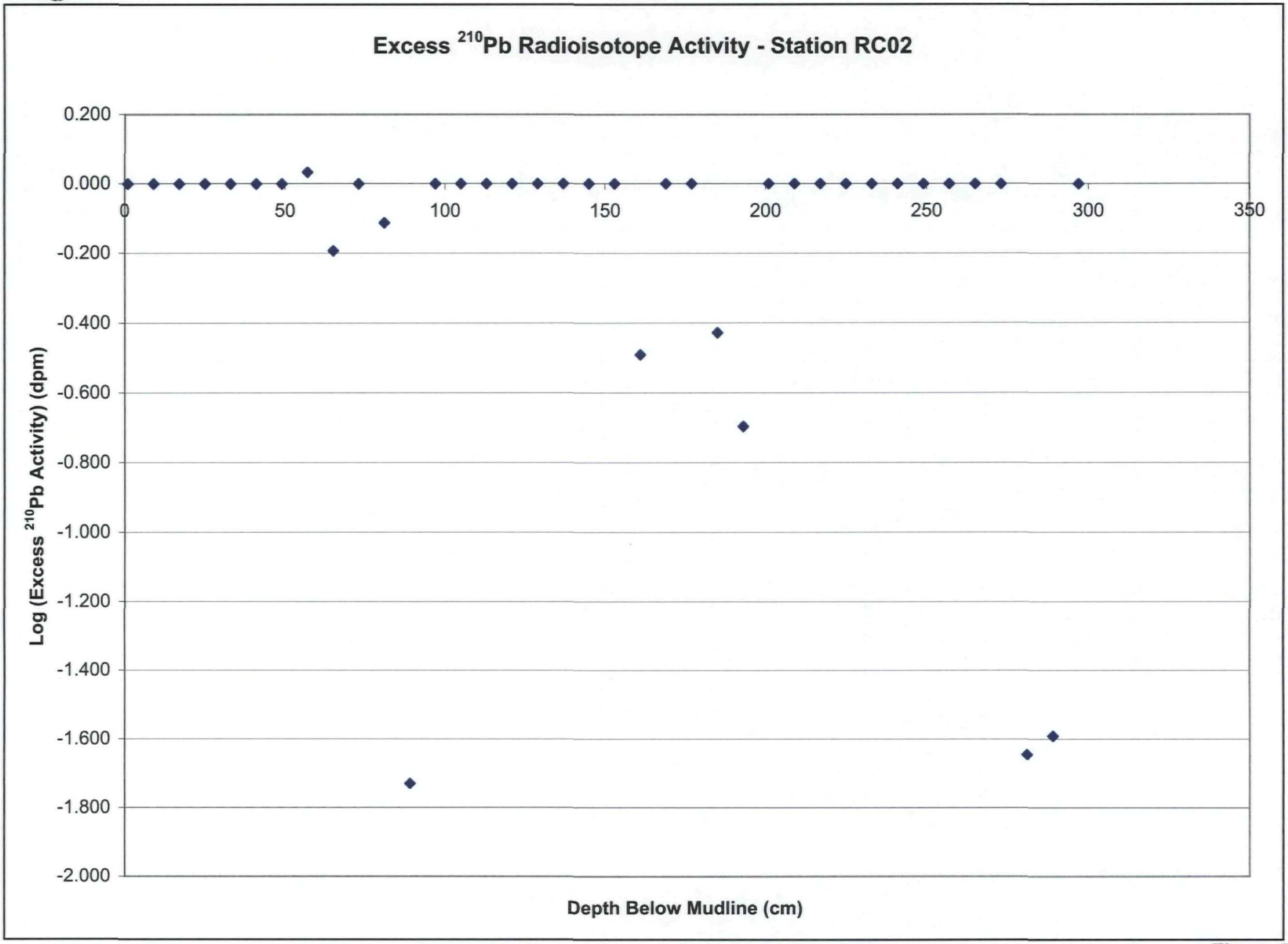


Figure 7
Excess Lead-210 Radioisotope Activity - Station RC02
Willamette River

ANCHOR ENVIRONMENTAL, L.L.C.

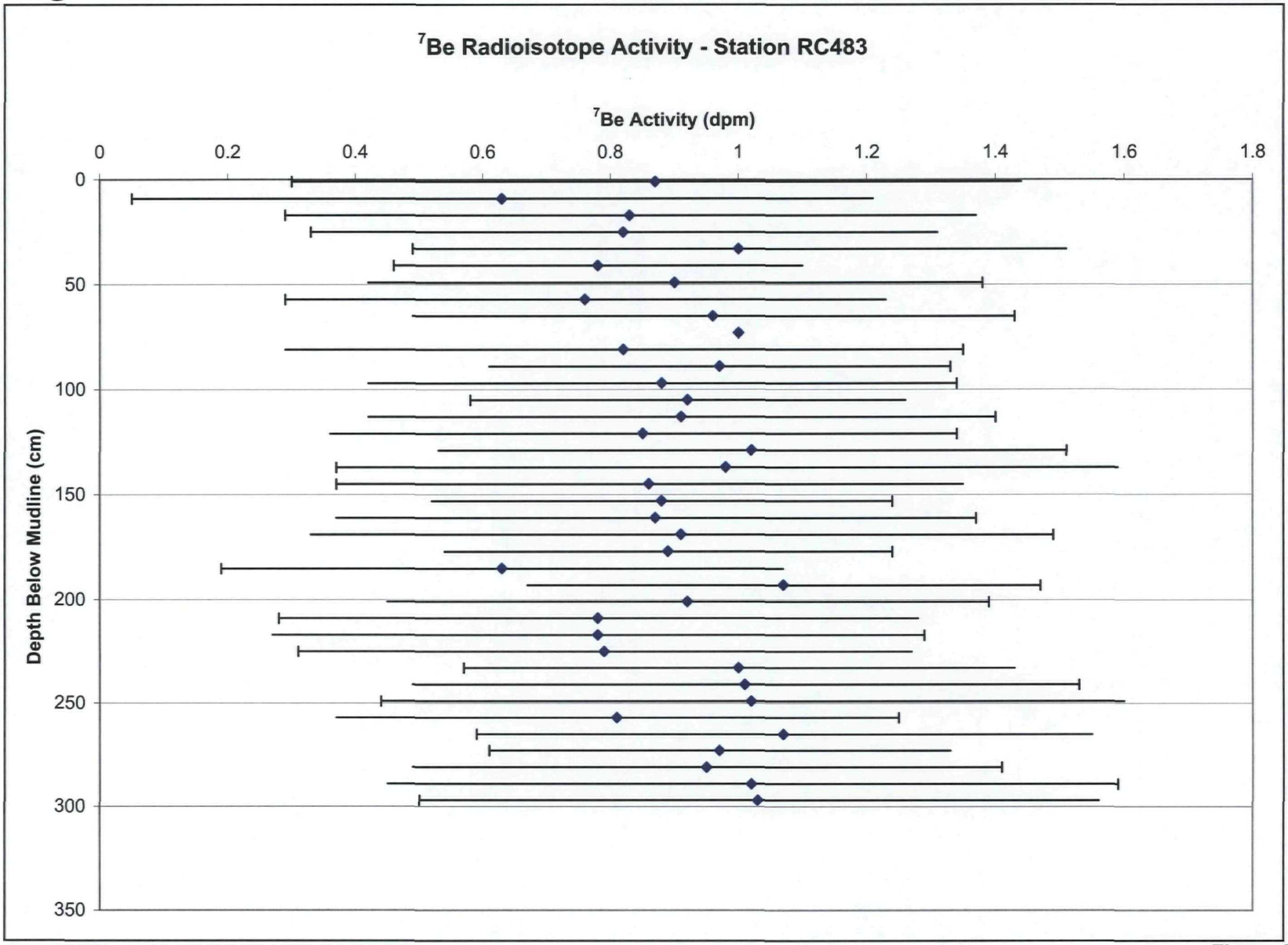


Figure 8
Beryllium-7 Radioisotope Activity - Station RC483
Willamette River

ANCHOR ENVIRONMENTAL, L.L.C.

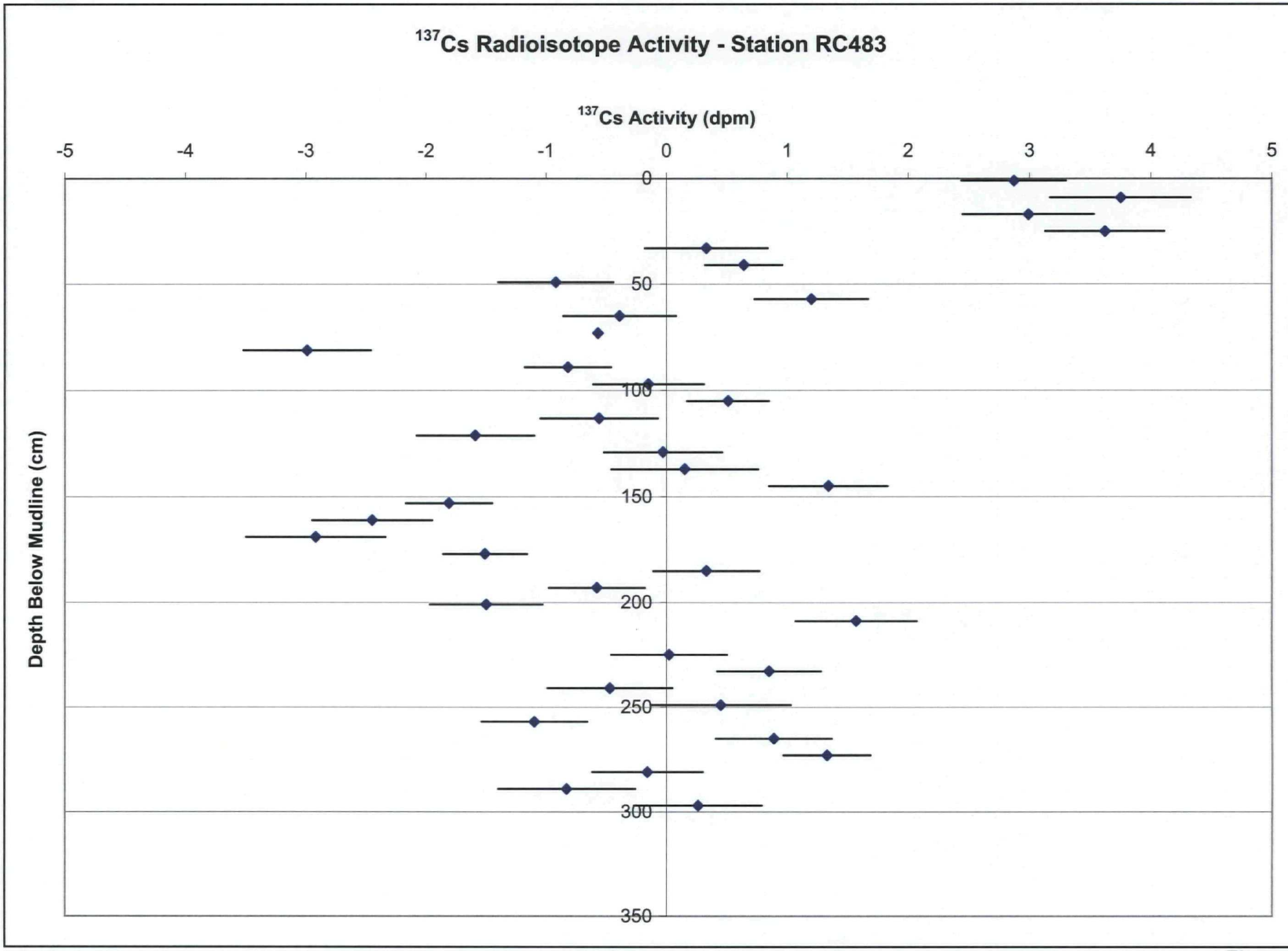


Figure 9
Cesium-137 Radioisotope Activity - Station RC483
Willamette River

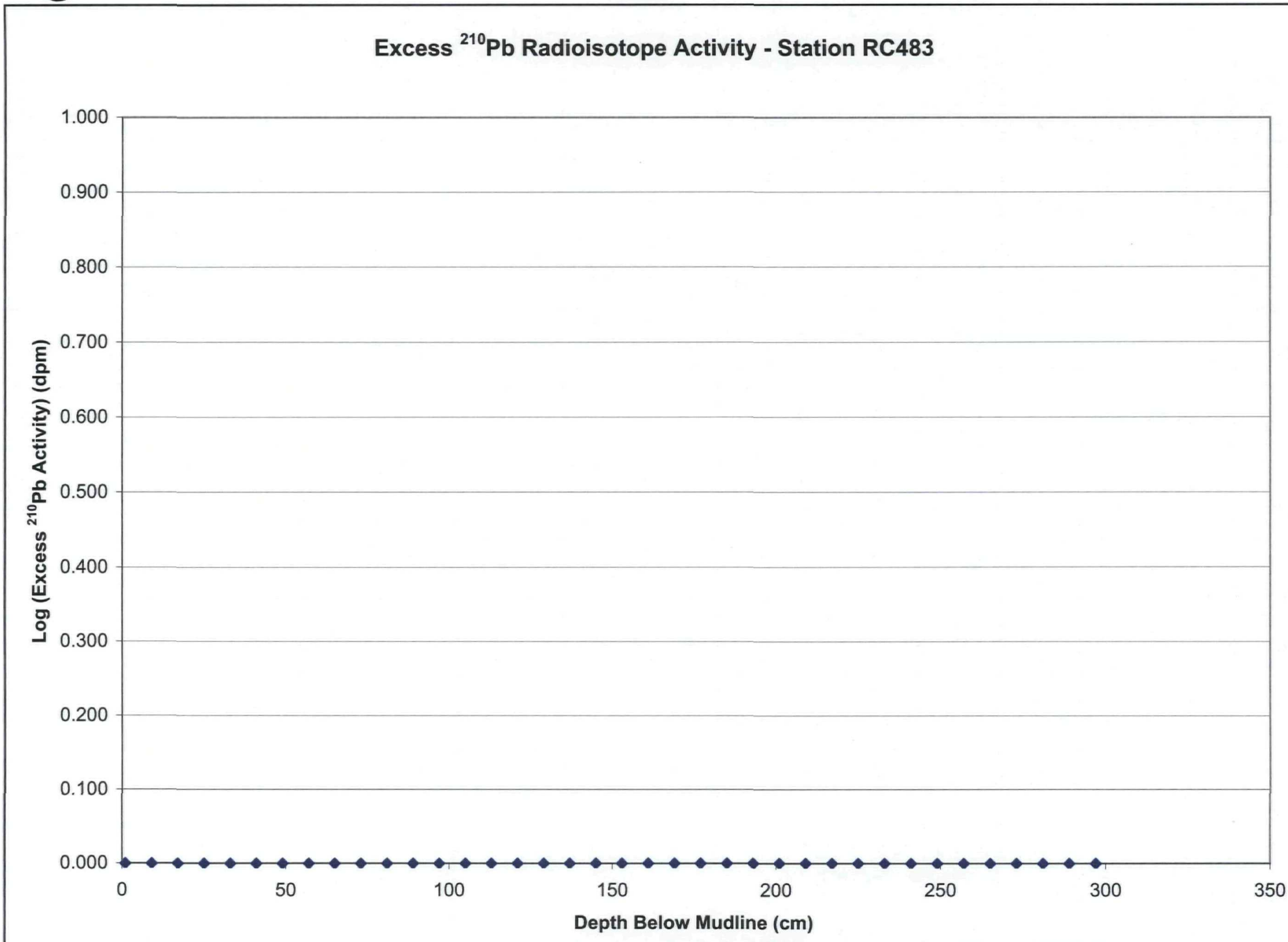


Figure 10
Excess Lead-210 Radioisotope Activity - Station RC483
Willamette River

ANCHOR ENVIRONMENTAL, L.L.C.

Attachment A – Radioisotope Core Logs

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SEDIMENT CORE LOG

PROJECT: Portland Harbor RI/FS

Core ID: RC01-1 pg 1 of 1

RADIOISOTOPE CORE

Collected:		**Processed:**
Date: Feb 6 /07	Drive Length: 14	Date: Feb 17 /07
Time: 1256	Tide Level (CRD):	Time: 0820
Recovery Length: 9.4'	Mudline Depth: 65	Core Length: 275
Recovery Efficiency:	Vessel: R.V. Nancy Anne (MSS)	Location: PTLD FIELD LAB
Crew: BP, DB & MSS		Crew: SF, JR, MT, AS, SW, JM

Depth in Core (cm)	Lithologic Description: (Grainsize, color, density/consistency, odor, organics, debris)	Grain Size (%) G	S	Si/Cl	Photo ID	FID/PID (ppm)	Sample ID
0-4	SILT w/ SAND. SAND is v. fine. Approx 30% organic debris. brown.		20	80			2 cm sample intervals to 10ft for RADIOISOTOPE ANALYSES.
4-58	Silt w/ tr fine SAND. Similar to 0-45 cm interval in RC01-2.		tr	100			
58-83	SAND w/ SILT. similar to 45-88 cm interval of RC01-2, except for 1cm thick silt lens @ 59cm.		90	10			137 SAMPLES TOTAL.
83-262	Clayey SILT w/ SAND. Similar to 88-224 cm interval in RC02-2 but w/ fewer sandy laminae observed. Thickest organic laminae @ 83-85cm and 255-260cm (plant debris) betw.		15	85			
262-275	Silty Clay. similar to 224-261cm interval of RC01-2.			100			

9ft

This is core RC01 core #3 on field collection log.

SF

Core segment breaks at (cm): 0-121; 121-244; 244-275. NO GAPS

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SEDIMENT CORE LOG

PROJECT: Portland Harbor RI/FS

Core ID: RC02-1 pg 1 of 1

RADIO ISOTOPE CORE

Collected:		**Processed:**	
Date: Feb 6/07	Drive Length: 14'	Date: Feb 6 /07	
Time: 1341	Tide Level (CRD):	Time: 1600	
Recovery Length: 10.9'	Mudline Depth: 55.2'	Core Length: 339	
Recovery Efficiency:	Vessel: R.V. Nancy Anne (MSS)	Location: PTLD FIELD LAB	
Crew: BP, DB & MSS		Crew: SF, JR, MT, AS, SW, JM	

Depth in Core (cm)	Lithologic Description: (Grainsize, color, density/consistency, odor, organics, debris)	Grain Size (%) G	S	Si/Cl	Photo ID	FID/PID (ppm)	Sample ID
0-8cm ~~8.5~~ 8F	SAND w/ SILT. SAND IS FINE, BROWN SIMILAR TO 0-8cm UNIT IN CHEMISTRY CORE.		90	10			2 cm sample intervals to 10 ft for ^{137}Cs ^{210}Pb + metals/Hg Analyses.
8-36	SILT w/ SAND. SIMILAR TO 8-40 cm UNIT IN CHEMISTRY CORE.		10	90			
36-49	SAND W/ TR SILT. SAND IS FINE. DK BROWNISH GRAY. SIMILAR TO 40-56 cm unit of chemistry core.		100	tr			
49-293	SILT W/ SAND. INTERLAM. + INTERBEDDED SILT + SANDS. SANDS V. FINE - FINE SIMILAR TO 56-312 cm UNIT IN CHEMISTRY CORE		25	75			
10.8 ft 293-328	SAND W/ SILT. SAND W/ TR SILT, W/ SILT lenses + lAMINAE (1-2mm thick) betw. 312-317 cm bml. SAND IS ~~V.~~ DK BROWNISH GRAY, DENSE, NO ODOR EXCEPT FOR THE MINOR SILT LENSES, THIS UNIT IS SIMILAR TO THE BASAL SAND IN THE CHEMISTRY CORE.		93	7			

NOTE BASAL SAND UNIT IN RADIOISOTOPE CORE IS LOCATED ~12 cm higher than in chem core.

Core segment breaks at (cm): 0-128 ; 128-251 ; 251-328

SF

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SEDIMENT CORE LOG

PROJECT: Portland Harbor RI/FS

Core ID: RC483-1 pg 1 of 1

RADIOISOTOPE CORE

Collected:		**Processed:**	
Date: Feb 6/07	Drive Length: 14'	Date: Feb 7 /07	
Time: 1544	Tide Level (CRD):	Time: 1230	
Recovery Length: 11.2'	Mudline Depth: 32.5'	Core Length: 324	
Recovery Efficiency:	Vessel: R.V. Nancy Anne (MSS)	Location: PTLD FIELD LAB	
Crew: BP, DB & MSS		Crew: SF, JR, MT, AS, SW, JM	

Depth in Core (cm)	Lithologic Description: (Grainsize, color, density/consistency, odor, organics, debris)	Grain Size (%) G	S	Si/Cl	Photo ID	FID/PID (ppm)	Sample ID
0-34	SILT w/ TR SAND. SIMILAR TO 0-29 cm IN RC483-2		tr	100			2cm SAMPLE INTERVALS to 10 ft for RADIOISOTOPE ANALYSIS
34-60	SAND w/ SILT. SAND w/ TR SILT w/ SILT LENSES IN UPPER 3cm. SIMILAR TO 29-46 cm interval IN RC 483-2.		80	20			
60-313	CLAYEY SILT. w/ SAND. SIMILAR TO 46-317 cm interval IN RC483-2. ~~except~~ SAF. meth. ves. to ~180 cm		10	90			
313-324	SAND w/ SILT. SAND w/ V THIN SILT LAMINAE + LENSES ≤1 mm thick DK BROWNISH GRAY. MILD ORGANIC ODOR. [SIMILAR UNIT NOT ENCOUNTERED IN RC483-2.]		90	10			
	This core is RC-483 Core #2 in FIELD COLLECTION LOGS						

Core segment breaks at (cm): 0-116; 116-239; 239-324

SAF